OCTOBER 27, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Mr. Stevens Rice
University Microfilms
313 North First Street
Ann Arbor, Michigan

High Strength Ceramics

Contents, Page 3

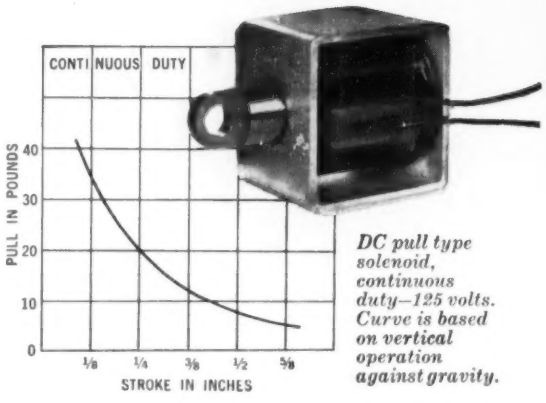
FARNSWORTH

100 MILLION OPERATIONS!

new ASCO solenoid has virtually unlimited life... outstanding economy

In this case "unlimited life" is a simple statement of fact. ASCO's new solenoid is manufactured to such precise tolerances (±0.0005") that wear is virtually non-existent. In ordinary solenoids, the plunger rides loosely in the sleeve—inviting wear. But in ASCO's long-life solenoid, the plunger is guided by a machine tool bearing that assures accurate stroking and reduces friction to an absolute minimum.

Because this solenoid was engineered with quality as the prime consideration, its initial cost is higher. However, it is in fact *the most economical solenoid you can buy* because, once installed, it can practically be forgotten. This solenoid will still be functioning 100 million operations later—long after standard types have been replaced—and replaced—and replaced. For additional information, contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

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Automatic Switch Co. 54A HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

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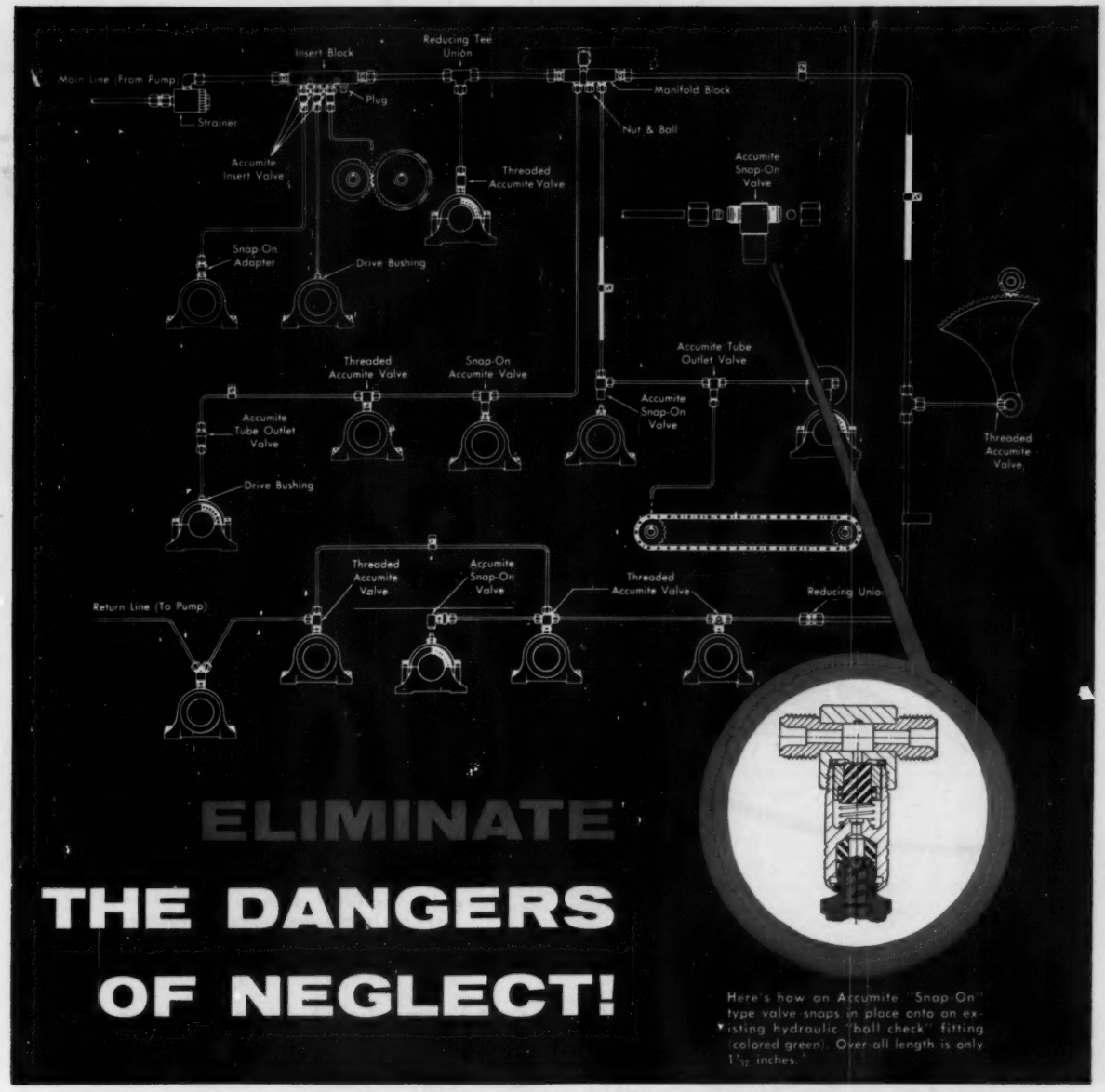

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The Alemite Accumite® Centralized Lubrication System comes complete with pump, metering valves and controls. Meters exact amount of lubricant to all bearings whenever system is operated by air, vacuum or manually at any predetermined frequency.

There's no need for a lubrication shutdown. No chance of work spoilage or bearing failure due to over lubrication. The Alemite Accumite System accurately meters .003, .006 or .009 cu. in. shots of oil or grease automatically. Is available with adjustable fittings for applications requiring measured metering from .003 cu. in. to zero. "Snap-On" and "Screw-In" type valves make for complete flexibility in converting existing systems to automatic operation.

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For complete details on Alemite Accumite® Centralized Lubrication Systems for large or small, stationary and mobile equipment (Canning and Labeling Machines • Tractor Trailers and Lift Trucks • Farm Implements • Machine Tools • Textile Machines • Any Machine or Vehicle with Moving Parts) write for your *FREE* Alemite Accumite Catalog . . . today!

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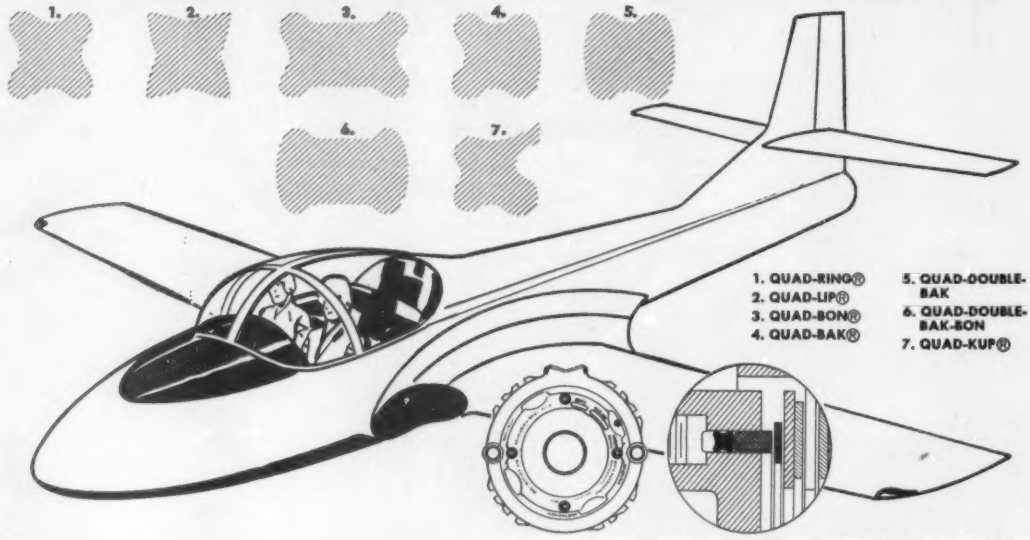
MINNESOTA MR RUBBER

FACTS for FILING on

SPECIAL QUAD-RING® DESIGNS



Quad-Bak—used as a power-transmitting dynamic seal installed on the Auto Specialties Manufacturing Co. aircraft brake.

QUAD-RING® BASIS FOR THE DESIGN OF A WHOLE FAMILY OF VERSATILE SEALS

QUAD-RING—An exclusive development of Minnesota Rubber to give outstanding service in a wide range of dynamic and static sealing applications.

QUAD-LIP—Developed for applications which require zero leakage at very low pressure differentials with minimum mechanical interference.

QUAD-BON—Provides maximum resistance to spiraling in the smallest space possible while maintaining the sealing characteristics of the basic QUAD-RING.

QUAD-BAK—Designed to eliminate damage to packing when subjected to extreme extrusion in one direction only.

QUAD-DOUBLE-BAK—A double acting packing for maximum resistance to extrusion while maintaining two effective sealing lips.

QUAD-DOUBLE-BAK-BON—Provides maximum resistance to both spiraling and extrusion in a double acting installation.

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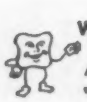
These special cross sections of the basic QUAD-RING design are just a few of the modifications possible to give complete versatility for any sealing application.

Manufactured under U.S. patents RE 24332 and 2,873,132, other patents pending.



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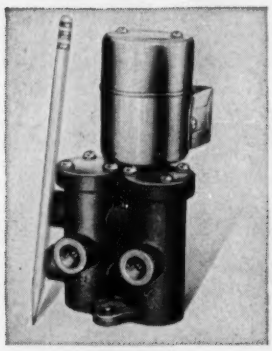
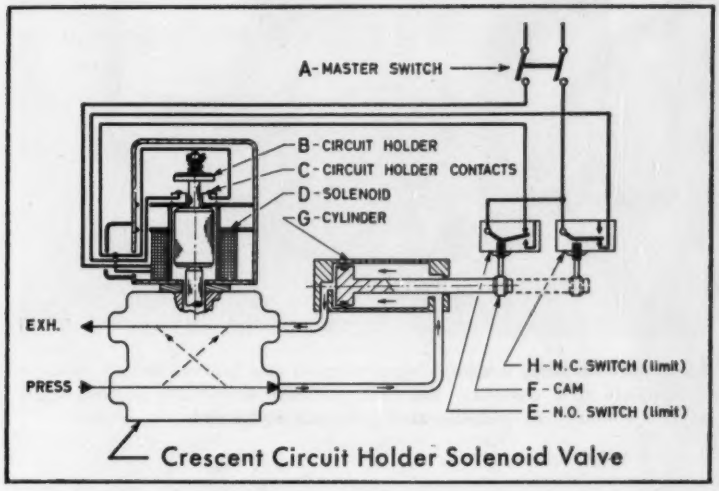
CRESCENT® CIRCUIT HOLDER SOLENOID VALVE



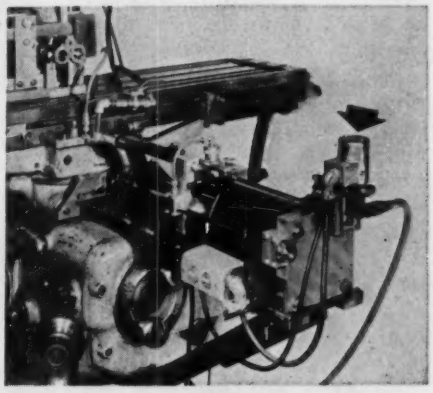
Compactness is an advantage of the unit.

to make cycling operations fail-safe

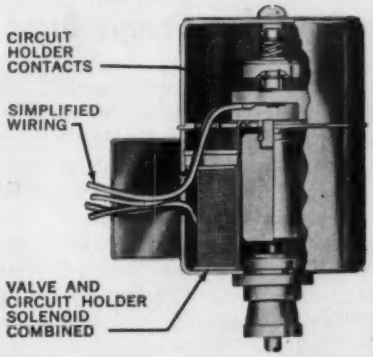
This new solenoid valve revises standards of circuit holder dependability on automatic cycling machines. Circuit holding action is performed by a specially designed, heavy duty solenoid (tested for 100-million cycle operation under conditions many times more severe than those encountered in any industrial application). Use of relays is unnecessary (see diagram), thereby eliminating one electrical circuit and avoiding an additional possible source of trouble. The Crescent Circuit Holder Solenoid Valve is applicable to automate machine tools, packaging machines, conveying machines, etc. Write for complete information and specifications (Bulletin No. 60809), or let a Barksdale representative demonstrate how Crescent Valves can save you money by cutting downtime.



In the starting position, the master switch is open, solenoid is de-energized and normally open switch is closed by cam. When master switch is thrown, the solenoid is energized. Air flow through the main valve is reversed and cylinder moves to extended position (dotted line). As cylinder rod moves, switch (E) opens; circuit holder (B) and switch (H) maintain the circuit. When rod is fully extended, cam opens switch (H), de-energizing the solenoid and reversing air flow. Piston returns to starting position. When cylinder rod is fully retracted, the solenoid is re-energized by closing of switch (E), and the cycle is repeated until the master switch is opened.



Typical installation of the new Crescent Circuit Holder Valve (arrow) on a milling machine set up for a boring operation.



The valve solenoid, which is designed to outlast the life of the valve, performs the circuit holding function.

Fail-Safe • Dependable

Eliminates relays and relay enclosures

Simplifies wiring

Saves space

Reduces installation time

Cuts electricity costs

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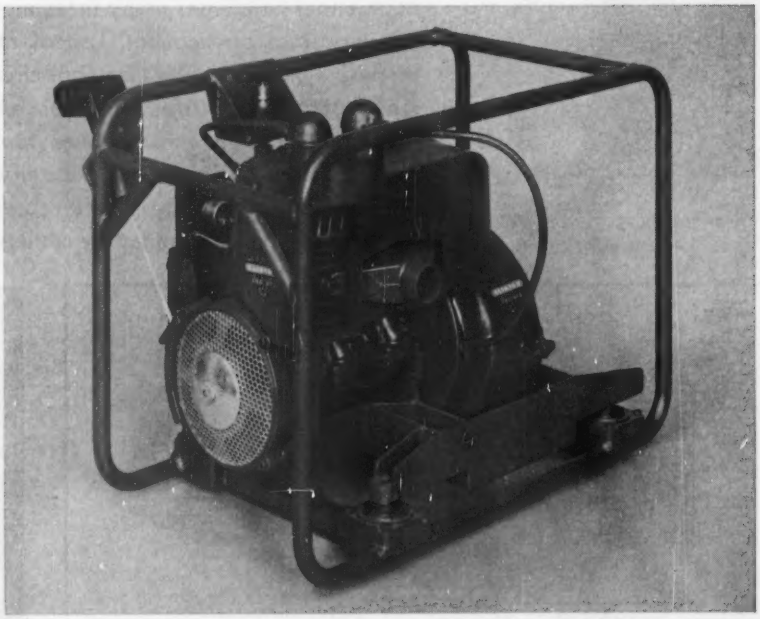
ENGINEERING NEWS

Two-Cycle, Two-Cylinder Engine Looks for New Jobs

NEW YORK — Another significant by-product of the missile program is searching for commercial application. It's a small (23 lb) surprisingly powerful (10 hp) gasoline engine, claimed to be the first to combine two-cylinder, two-cycle operation.

Designed by Clinton Engines Corp., Clinton, Mich., the portable powerplant is currently being used in Army's Martin-LaCrosse missile system.

Because of its high power-to-weight ratio (comparable four-cycle engines weigh about 100 lb), Clinton predicts that the new two-stroker will "revolutionize the design of power equipment for industrial and consumer use." Possible near-future applications include portable pumping equipment; portable generators that will deliver exceptionally high power; heavy-duty chainsaws and other similar equipment that is now only "semi" portable; outboard motors.



Power for a first-line Army missile is supplied by a new bantam-weight gasoline engine. Coupled to a generator the hand-portable powerplant delivers 2100 watts at 120 v, energizes ground-based guidance equipment.

Two Big Labor Groups Draw Bead on Engineers

WASHINGTON—Brushing aside recent rebuffs by professional employees at Western Electric and Sperry Gyroscope, two giant AFL-CIO unions have pledged to bolster their lagging memberships with big drives on professional and technical employees. Their efforts are outlined in the current *Engineering Employment Practices Newsletter*, published by the National Society of Professional Engineers.

I.U.E. Task Force

Citing a 10 per cent drop in membership in the last four years, IUE President James B. Carey exhorted delegates at the union's September Miami Beach convention for a 50 per cent dues increase, saying that he plans to put 50 new organizers in the field to spearhead the new drive for white-collar workers.

National Engineering Council

To aid the new organizers, the IUE delegates passed a resolution to form a National Engineering Council, membership of which will be restricted to IUE professional and technical units. Text of the resolution stressed that production workers and professionals "belong together" and said that "IUE has demonstrated that clerical workers, technical workers, and professional engineers can be organized; that they can become dedicated workers within the labor movement."

At the September Grand Lodge Convention of the International Association of Machinists in St. Louis, a similar resolution was passed calling for the IAM to "set up a program of organization of technical, office, white-collar, and professional workers in our traditional areas of interest . . . Fortunately, IAM already has a sizable core of technical and office workers organized in some of the larger aircraft plants, constituting a firm foundation for future organizations."

Togetherness

IAM delegate Dorothy Moellring, a member of the Lockheed local, renounced the "special approach" method for organizing white-collar workers. "What we want is for the people who have not organized the office and technical people in our industry to consider them the same as machinists who work with their hands," she said. Experience has shown that office and technical people can be organized just as easily as shop people "when they realize the benefits they can obtain."

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All-metal drives use single-roll chains to achieve positive, stepless, infinitely variable speed control

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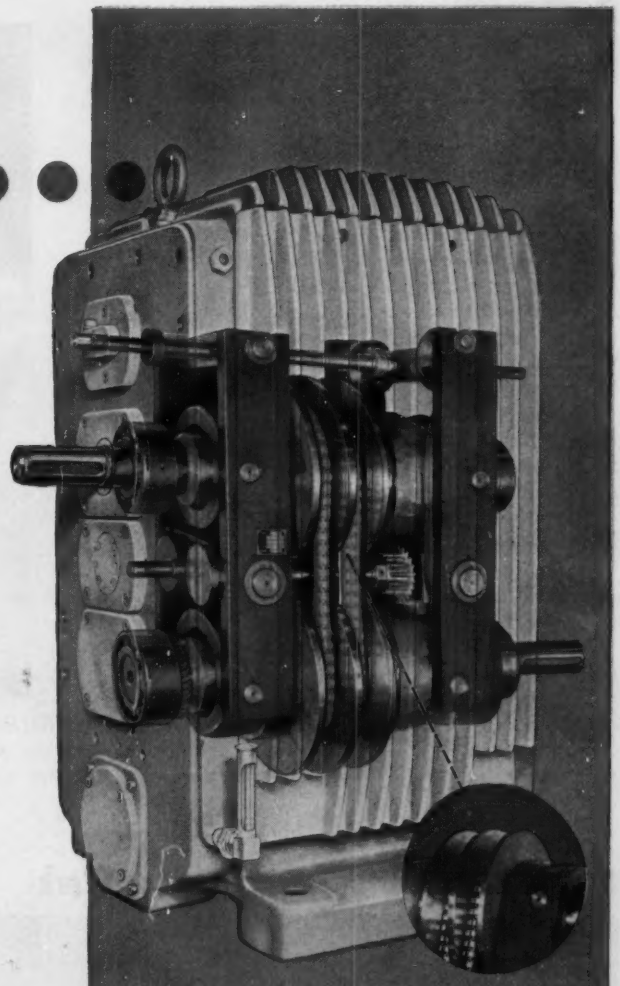
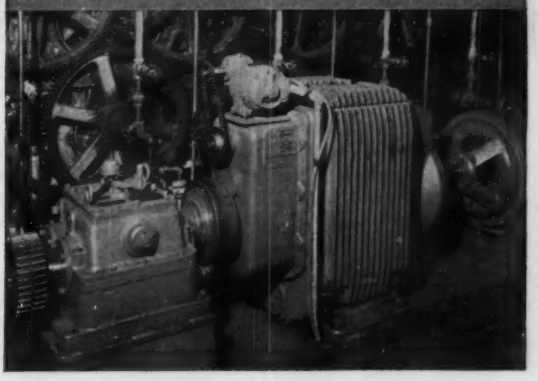
Twin strands of high-load capacity chain operating between opposing conical wheels permit extreme compactness. The effective diameters of the wheel faces are altered during operation, changing their ratio and the output shaft speed accordingly . . . providing smooth, positive, accurate speed adjustment between maximum and minimum settings. Constant hp or torque is maintained over the complete speed range.

Link-Belt RS P.I.V. drives are all-metal and pressure-lubricated. Capacities to 50 hp, with speed variation ratios up to 5.5:1. For full details, contact your nearest Link-Belt office. Ask for new Catalog 2874. 15,267



RS-33 P.I.V. with twin chain arrangement for capacities to 50 hp. Inset shows close-up of unique all metal single roll chain construction.

47-ROLL PAPER-MAKING MACHINE uses Link-Belt RS P.I.V. on primary drive. The RS P.I.V. powers a two-speed gear drive which enables paper speeds to be varied over two ranges . . . 4 to 16 yards per minute and 12½ to 50 yards per minute.



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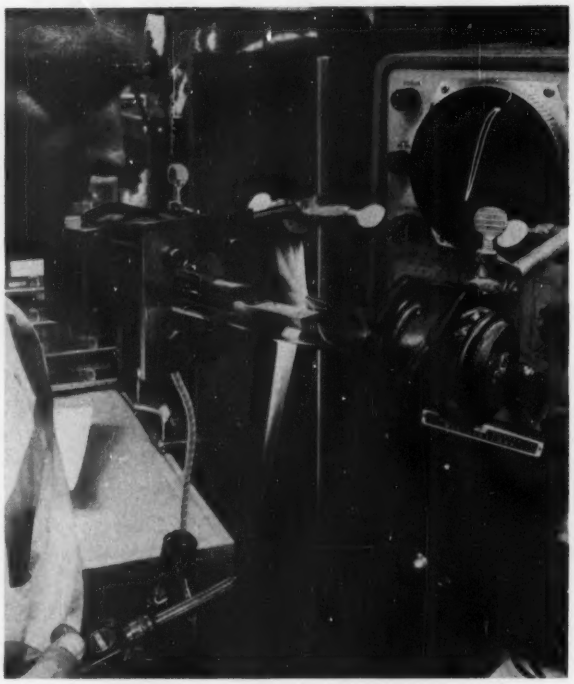
White-Hot Success in Electronics

PITTSBURGH — A high-temperature transistor has been developed that can withstand temperatures in excess of 650 F. Made of silicon carbide, it amplifies and has power gains greater than unity up to 670 F, and with further development may operate at temperatures ranging to 925 F, according to Westinghouse Electric Corp.

Although still in the laboratory stages of development, the transistors incorporate significant advances in semiconductor technology, according to Westinghouse. Two developments that have made the device possible, for example, are production of silicon carbide crystals of exceptional purity, and perfection of techniques to form a junction in the material.

The transistors are made from crystals about 0.002 in. thick. Junctions are then built into the material by exposing it to vaporized aluminum at 3900 F. Diffusion of aluminum into the silicon carbide transforms it from an n-type material to a p-type, and forms a surface that can be controlled to within a few millionths of an inch.



Visible proof of a new transistor's successful high-temperature performance is traced on oscilloscope, as the transistor — a tiny speck within the quartz tube — is heated to 650 F.

Record-Breaking 'Copter Ready for Work

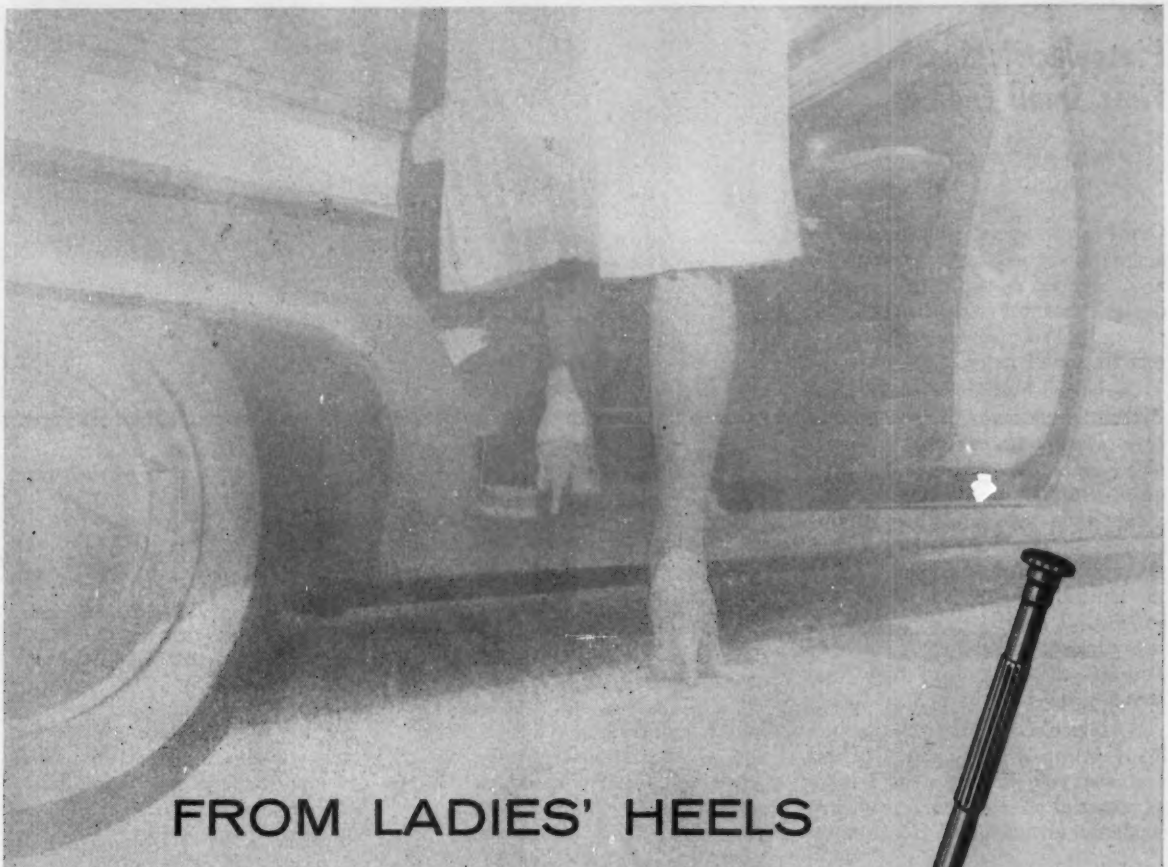
Whirlybird for executives—complete with plush interior—is one version of Cessna's four-place Skyhook. Large detachable wheels provide ground mobility.

WICHITA, KANS.—Boasting an impressive flight record (three world altitude marks) during five years of development, Cessna Aircraft's Skyhook helicopter is ready to invade the commercial-aircraft market.

Mechanical simplicity and ease of handling have been keynotes in design of the craft. The entire drive system for both rotors incorporates only five gears; engine is mounted horizontally, eliminating special lubrication or induction systems. Handling qualities are enhanced by a new, Cessna-designed maximum-airspeed indicator. The pilot merely adjusts the indicator for the gross weight of the aircraft at its particular altitude, and the airspeed red line indicates the speed limit.

Another Cessna-designed instrument, consisting of a mechanically driven gyro which supplies an input to the rotor-control system proportional to the aircraft's roll rate and displacement, gives Skyhook exceptional stability.

Powered by a 270-hp Continental engine, the craft cruises at 90-120 mph, has a 400-mi range.



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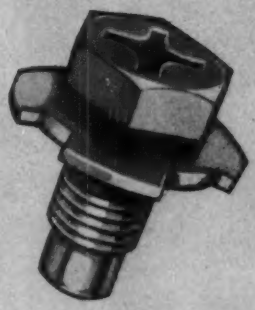

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Circle 408 on Page 19

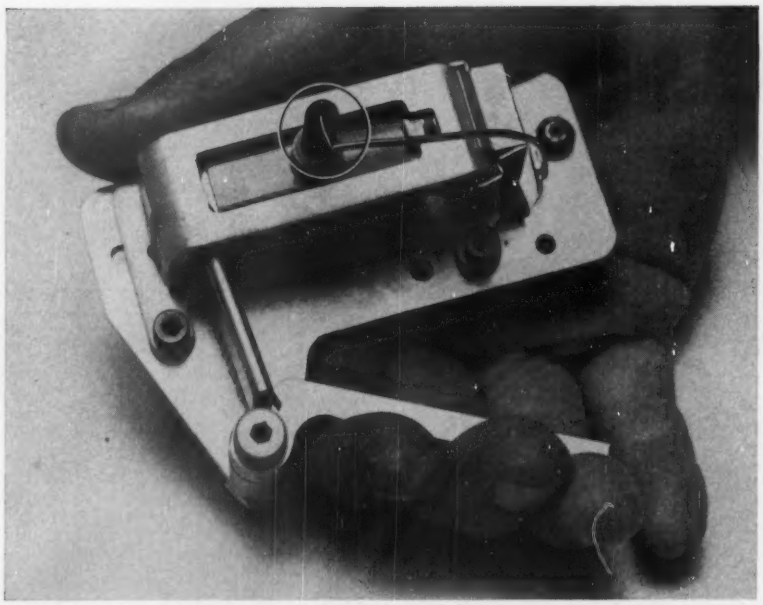
Piezoelectric Spark Fires Small Engine

Ignition System Eliminates Magneto, Coil, Condenser

CLEVELAND—Spark Pump converts a single short motion into a 20,000-v arc. Smaller than a man's fist, the device is teamed with a switch and sparkplug in a complete ignition system for small motors.

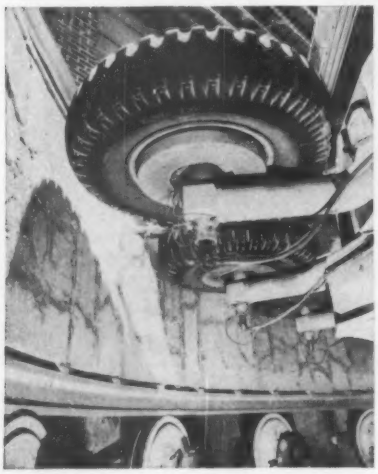
Developed by Cleveland Graphite Bronze Div., Clevite Corp., for power mowers, outboard motors, portable generators, and other small engines, the pump produces a constant high voltage at all engine speeds. Because voltage is constant, the unit needs no complex starting mechanism—engine starts with a single pull on the starting cord. A heavy spark is fired by the pump (through the spark plug) even when the electrodes are burned or fouled.

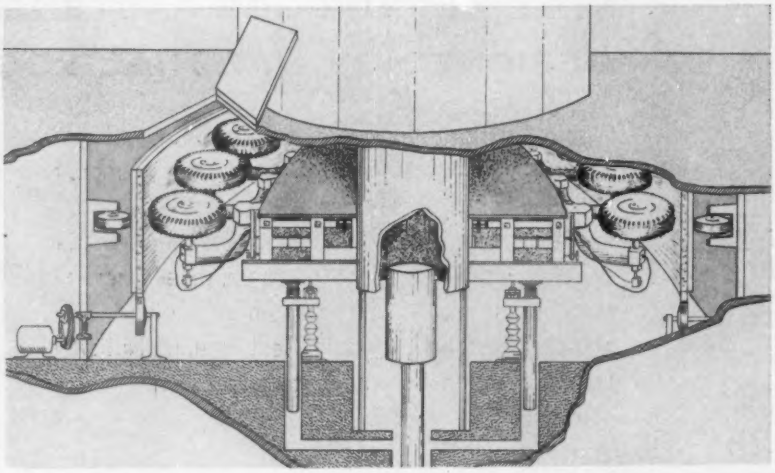
A piezoelectric device, Clevite's Spark Pump is the first unit of this type that can produce a spark twice as powerful as that from a magneto-condenser arrangement. Consequently, the ignition system does not need any of the familiar ignition components—magneto, points, coil, and condenser. According to Clevite spokesmen, Spark Pumps might be used for ignition of multicylinder engines in the future. In any case, development work will continue, as the company hopes to make the system smaller and simpler.



Hand pressure generates a 20,000-v arc (above) in the demonstration model of Spark Pump, a new electric ignition system developed by Clevite Corp. Designed for power lawn mowers, outboard motors, and portable generators, the device will be optional on the '61 line of Clinton engines.

Rotating Road Tortures Army Tires





Held against a cylindrical revolving roadway, tires destined for the Army's Tank-Automotive Command are now life tested indoors. Equipment, developed by the National Bureau of Standards, controls slip angle, speed, load, temperature, inflation pressure, and other factors. Indoor and field-test data show the same results, and indoor tests are much easier to conduct. The "road," a 28-ft diam steel cylinder lined with 3 inches of concrete, rotates at speeds of up to 65 mph. Streetcar wheels driven by twelve 20-hp motors support the cylinder. Tires are mounted on carriages that extend out from a central platform. Air-spring assemblies load the carriages which, in turn, force the tires against the concrete. An eccentric connected to each carriage varies slip angle. Tread wear is measured by weighing the tire before and after each test run. Data indicate that wear rate increases exponentially with slip angle, except for very small angles. Tires tested vary from 6.70 x 15 passenger-car size to 11.00 x 20 truck tires.

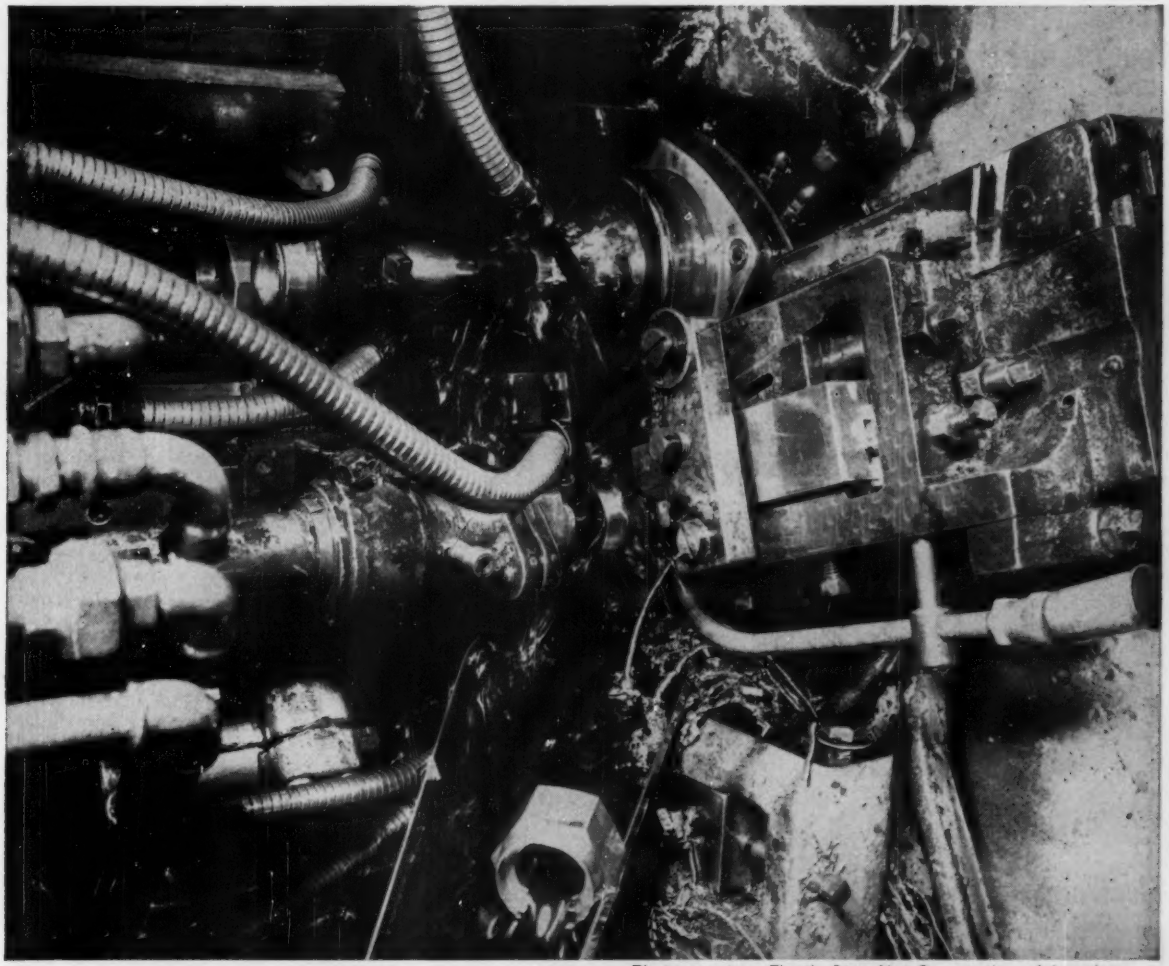


Photo courtesy Elastic Stop Nut Corporation of America

Nuts . . . ESNA makes millions of them from Aristoloy Electric Furnace Steel

Steel for self-locking hex nuts must be uniform in structure, easy to machine and free from internal and external defects. Elastic Stop Nut Corporation of America insists on these qualities . . . and gets them with Aristoloy cold finished bars.

Aristoloy Electric Furnace Steels, carefully controlled from melt shop to finishing operations, meet specifications for this and other applications requiring steel of uniform quality.

For complete information about Aristoloy blooms, slabs, billets and bars, in carbon, alloy, stainless and leaded, call the Copperweld representative in your nearest large city . . . or write for NEW PRODUCTS & FACILITIES CATALOG.

ARISTOLOY STEELS

DIVISION OF
COPPERWELD
STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

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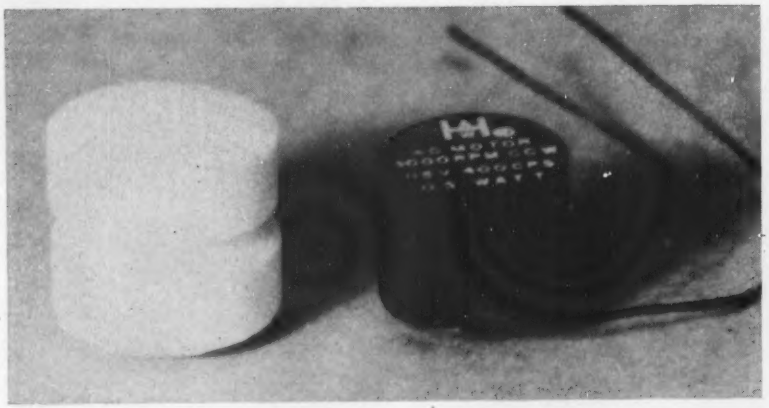
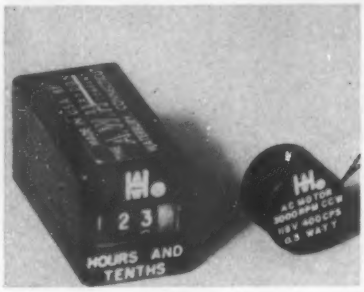
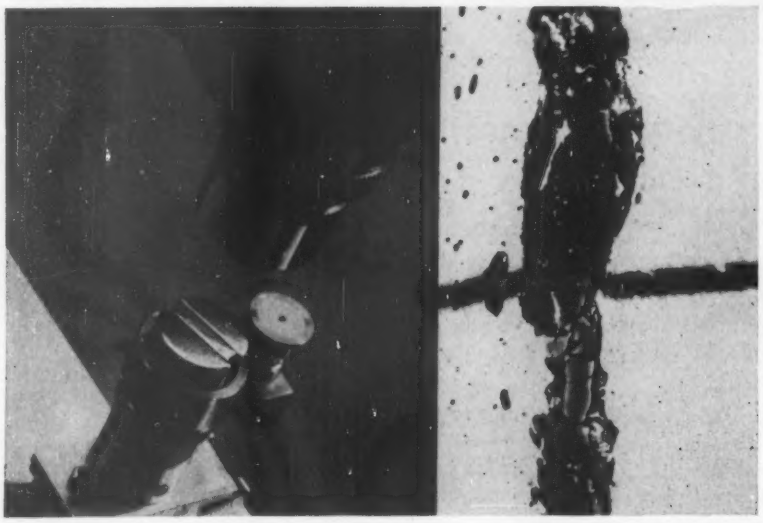
Ten Motors to the Cubic Inch





Aspirin-size solution to an airborne timer-drive problem is a hysteresis motor rated at 1.5×10^{-6} hp. A. W. Haydon Co., Waterbury, Conn., uses the "world's smallest" electric motor as a power source for the smallest digital elapsed-time indicator ever manufactured (left). Four-digit timer is ½ in. square by 1-1/16 in. long. Motor is ⅜ in. diam by 9/32 in. long, weighs 1/9 oz. Operating on 115 v, 400 cps, it requires less than ½ watt.

Electrons Probe Steel to Perform Chemical Analysis



Chemical analysis of minute segments of steel is now possible by merely looking at a specimen through an electron probe microanalyzer. The new instrument, installed at the Graham Laboratory, Jones and Laughlin Steel Corp., Pittsburgh, could hold the key to better steel, says J&L vice president for research, Dr. H. S. Turner. It permits combined study of microstructure and chemical composition better than even the best microchemical method; it doesn't alter the sample or its surrounding structure. A high-energy electron beam excites an x-ray emission from atoms within the region under examination. Each element gives off an identifying x-ray that can be measured with crystal analyzers and Geiger counters. Quantitative analysis can be performed on as little as one millionth of one billionth of an ounce.

Topics

"Custom-built" compact car is scheduled for production next year by Seagrave Corp., a fire-engine builder. Two-door coupe, two-door sedan, and station-wagon body styles will be made, and four, six, or eight-cylinder engines will be offered. Chassis and body of the Volkswagen-size car are to be hand-crafted; indicated price is around $3000.

• • •

British telephones may soon chirp like birds instead of ring like bells. Sounds which do not require as strong an impulse as the conventional ring are being tried out for use beginning next year, when an electronic telephone system will be put into operation. In the new system, electric impulses will perform tasks now assigned to switches and relays.

• • •

Hand-scrubbing machine for surgical teams cuts time required for preoperative cleansing from ten minutes to one minute. The machine, invented by John H. Alcamo of Newark, N. J., has a set of revolving brushes for each hand. The user controls flow of detergent, germicide, and water.

• • •

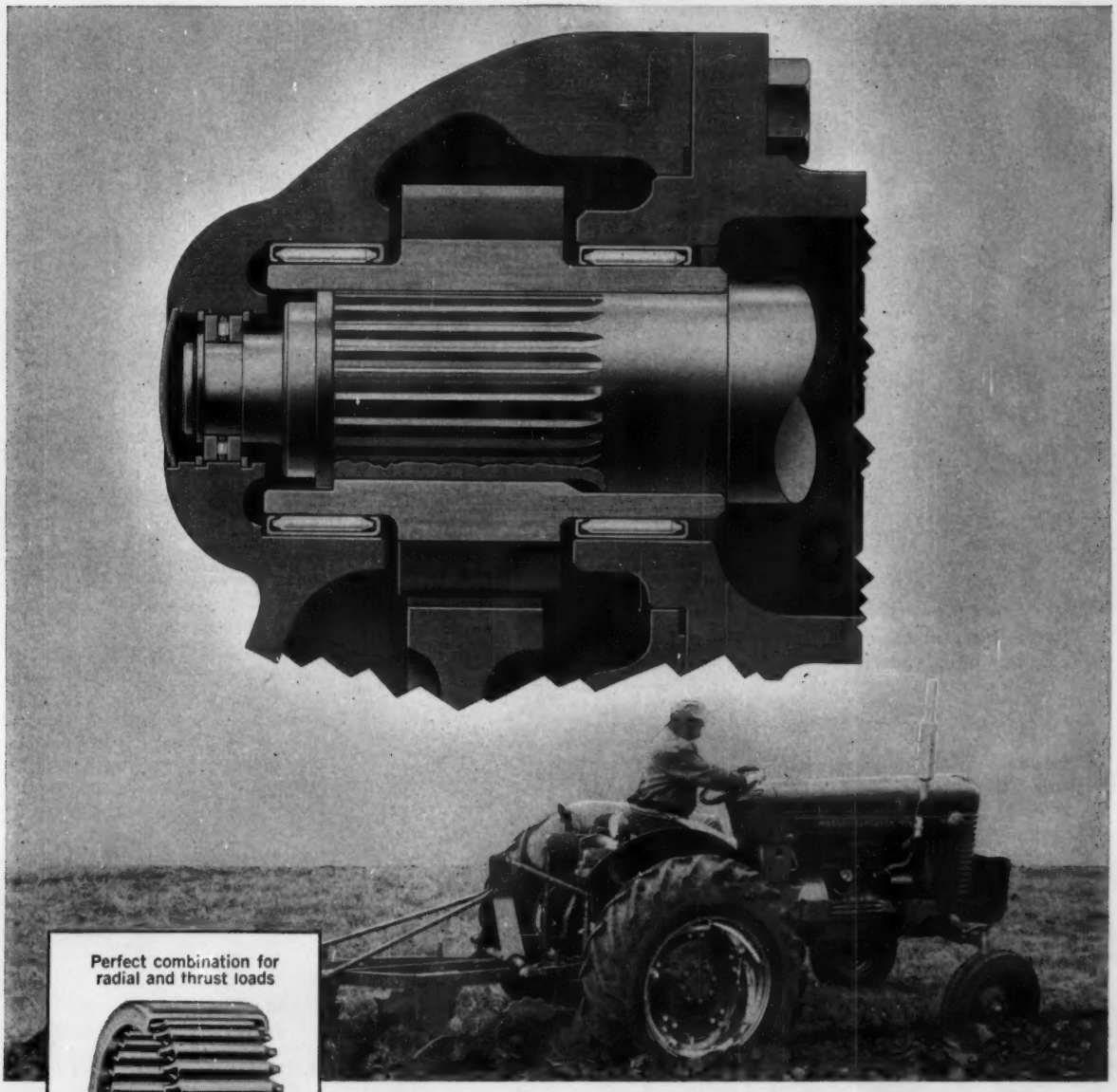
An air conditioner becomes a relic with the donation of the first centrifugal refrigeration compressor to the Smithsonian Institution. The compressor, developed by Dr. Willis Carrier and first used in 1922, will be featured in a permanent refrigeration exhibit to be opened by the museum in 1962.

• • •

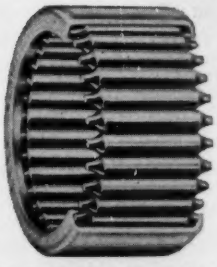
Electronic brains are blackballed by middle management, according to a survey by the Institute of Motivational Research for *Modern Office Procedures*. Members of this middle group advise top management against purchasing the machines, says the survey, because they fear computers will reduce the middle-management job to running machines and, eventually eliminate it.

• • •

Habits of the herring soon will be public knowledge, thanks to atomic radiation. At the AEC-owned Hanford atomic plant, General Electric Co. employees are irradiating 9000 fish tags which will be injected into herring to be released in Alaska. In years to come, when catches of herring are brought to canneries, the irradiation will make it possible to detect and remove tagged fish from the piscatorial masses traveling on fast-moving conveyor belts. The radioactive exposure is small enough that it will not harm the fish, even over a long period.



Perfect combination for radial and thrust loads



Torrington Needle Bearing

Torrington
Needle Thrust Bearing

For the big pull in tractor performance... Torrington Needle and Needle Thrust Bearings

On the world-famous Massey-Ferguson Model 85 Tractor more than 40 Torrington Needle Bearings and Needle Thrust Bearings are used to smooth the transmission of power, operate the power steering, and to provide improved bearing efficiency and operation.

One outstanding application is the drop axle gear set, pictured above. Here, with their full complement of small diameter rollers, two 2¾" shaft size Torrington Needle Bearings provide higher radial load capacity than any other bearings of comparable cross section. To handle the thrust load, a single Torrington Needle Thrust Bearing, with two races, is used to complete the bearing team. The result is smooth, efficient, reliable performance – at greatly reduced cost over bearing arrangements previously used in this type of application.

The combination of Torrington Needle Bearings and Needle Thrust Bearings pays off wherever compactness and high bearing capacity are needed. For advice on *your* application, call on Torrington – maker of every basic type of antifriction bearing.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

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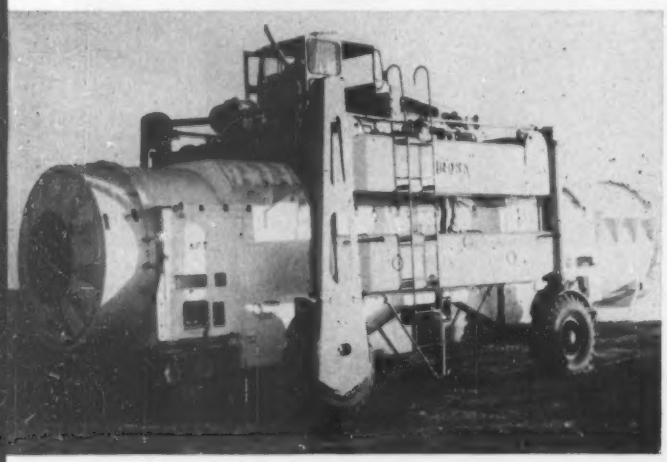
ENGINEERING NEWS

PICTURE REPORT

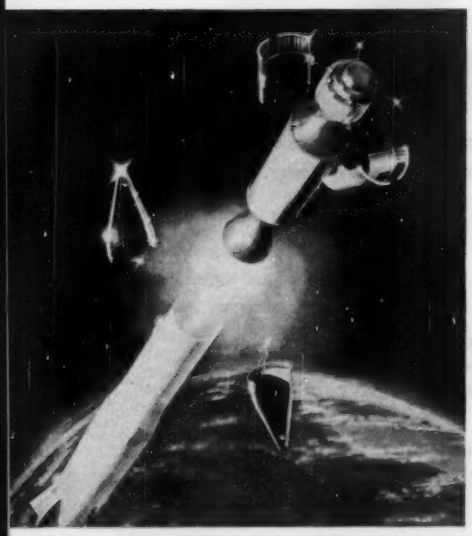
Two outboard motors power the Yamaha, a Japanese boat which was exhibited in a recent Chicago show. The craft is 22 ft long, has an 11-ft beam, and seats 10 persons.

Transporting a Polaris missile requires the services of a special container and a straddle carrier built by Clark Equipment Co. The container is fitted with shock absorbers and provides constant temperature, pressure, and humidity.



Nuclear powerplant in a small package could provide up to 30 kw of electricity for satellites and manned spacecraft. General Electric engineers who developed the capsule (a model is illustrated) say it is the simplest and most direct method for generating power from fission sources. Reactor for the proposed system is a thick-walled graphite cylinder; fuel is encased in channels in the cylinder wall. Thermionic cells in a surrounding shell convert 3100-F heat to electricity. Compactness, long life (it could operate unattended for as long as five years), and relatively high power output make the system better suited to space service than solar cells or chemical batteries, according to GE. Modular units can be combined to provide up to 300 kw.

Radiation-resistant solar cell, the small disc surrounded by a coating of white phosphor material and mounted on a copper block, is tested in a Van de Graaf particle accelerator. These new cells have shown the ability to withstand more than ten times the exposure to high-energy ionizing radiation than standard cells and are four times more resistant to exposure to protons with an energy of 740 million electron volts. They are made by diffusing phosphorus into the surface of a p-type silicon crystal; present cells use boron and an n-type silicon crystal. The process was developed by Army Signal Corps scientists at Fort Monmouth, N. J.



A 33-lb payload was carried to an altitude of 17,000 miles in the first launching of an Air Force Blue Scout Junior research rocket. This launching began a program which has scheduled about 35 vehicles a year for investigation and testing purposes. Blue Scout Junior, a comparatively low-cost rocket, is built and launched for less than a half million dollars. System engineer and payload carrier contractor is the Aeronutronic Div. of Ford Motor Co.

THIN
...BUT
PRECISE

Cutaway showing built-in shields

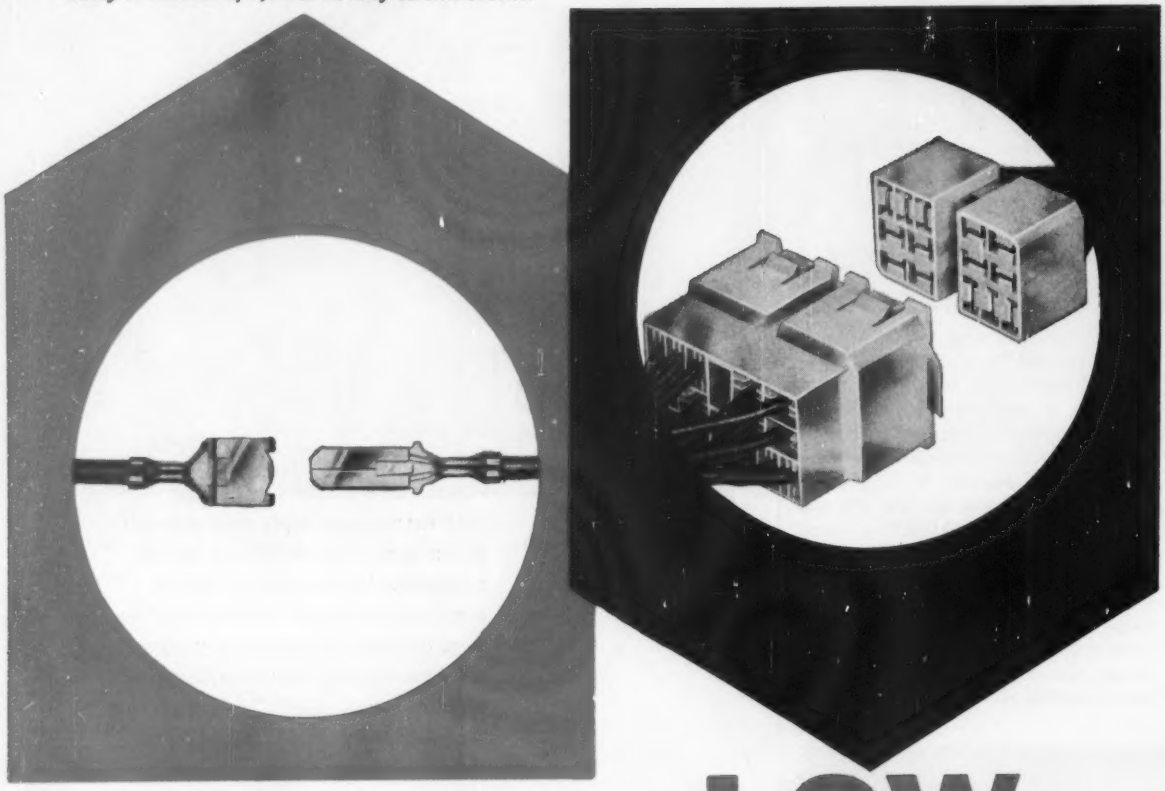
A ten-inch thin section bearing with extreme precision was the tough design specification GPL set for the supporting bearing in their Radan aerial navigation device. To meet these requirements ITI custom engineered a 4-point contact bearing with spring separators and shields, holding bearing torque to less than 6 inch-ounces under 40 pounds thrust, and maximum raceway runout to 0.0002" TIR. Complete technical data on this extra-thin bearing is available in our Tech-Tonic #8, or for information on how ITI can design and produce in quantity other special bearings having corrosion resistance, unusual configuration, or high temperature capabilities, write for Bulletin AFB-2.

ITI

INDUSTRIAL TECTONICS, INC.
manufacturers of precision balls and bearings
BEARING DIVISION | 18301 SANTA FE AVENUE, COMPTON 7, CALIF.

HIGH

20-25 amperage rating for greater design flexibility . . . choice of 7, 14 or 20 way circuit blocks.



LOW

2-5 pounds insertion and extraction force for easier installation and servicing.

NEW AMPEEZ CONNECTOR GIVES YOU BOTH

Here is a workhorse of a connector! Housed in tough nylon and designed to carry as many as 20-circuits while holding insertion-extraction forces to 2-5 pounds, AMPEEZ Connectors are adaptable to many applications calling for a heavy-duty, easily serviced multiple-circuit disconnect.

AMPEEZ Connectors will match your application needs perfectly . . . anything you call for up to 20-circuits and 25 amps. One other major feature! *AMP's exclusive Tab-Gap Lok assures a constant contact pressure even under the severest vibration conditions.*

Use AMPEEZ Connectors, eliminate the human error in individual connections . . . make them fast and safe. Send today for AMPEEZ Connector literature and sample of tab and receptacle with Tab-Gap Lok.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

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Reader Information Service

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406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
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423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	845	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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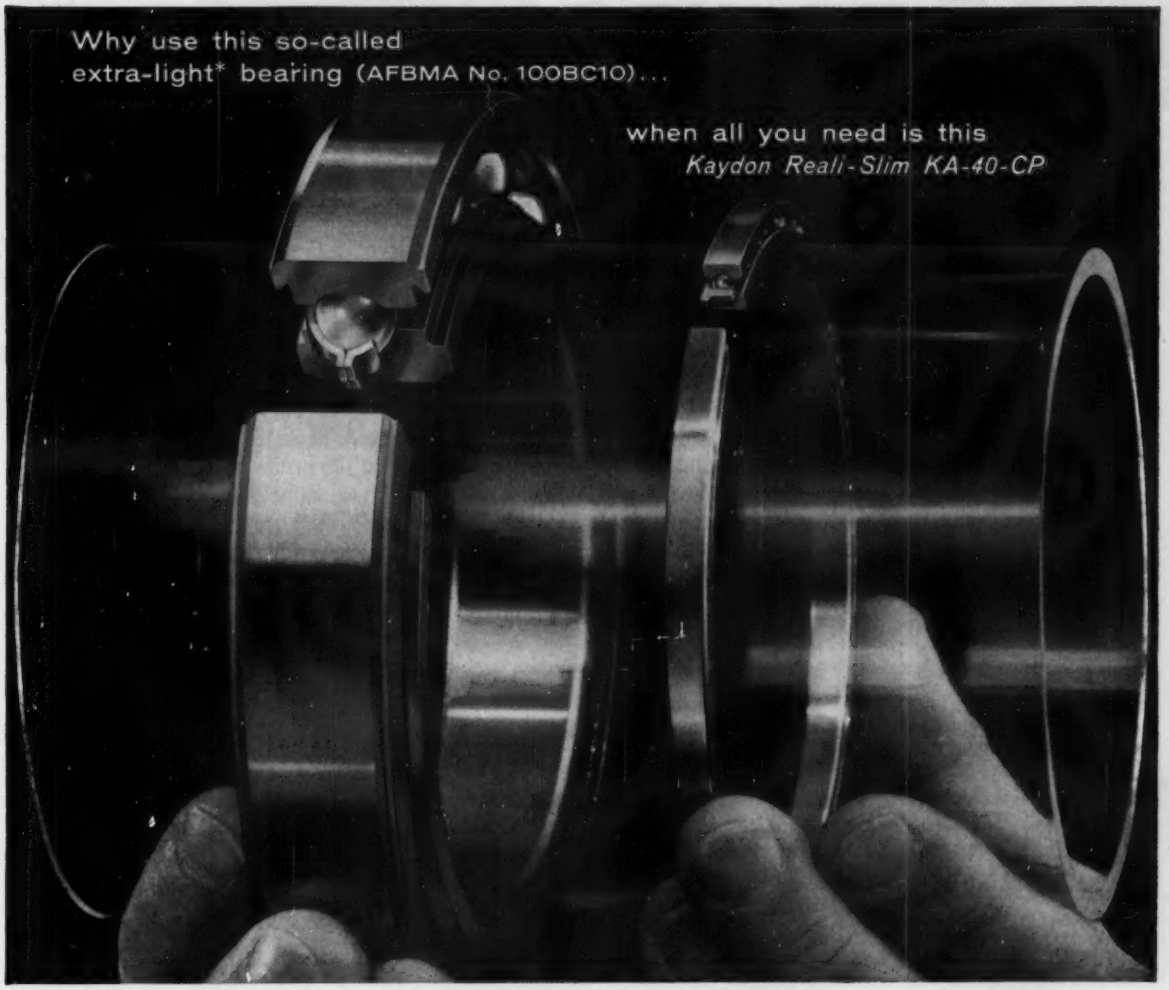
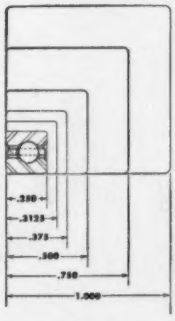


News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

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K-160

Circle 413 on Page 19

Camp Century—stepping stone to a moon base

Know-how gained during erection of a nuclear powerplant on the Greenland Icecap may be a big help is establishing manned bases on the moon, Army engineers explained at a recent ASCE convention. The Camp Century installation, located on top of an iceberg, is furnishing enough data to make large-scale polar operations feasible, a first step towards sustaining life on the moon and beyond. Problems faced in Greenland are, in some ways, more unusual than those expected on other worlds. For example, elevation of the icecap stays constant, even though three feet of snow fall each year. Because equilibrium is maintained by plastic flow into the ocean, all permanent installations must either be buried or raised above the ice.

automated research in the U.S.S.R.

Research will eventually grow into a separate industry, with specialization, co-operation, and automatic machines as its tools. So said a prominent Russian scientist in an address to the International Congress on Automatic Machines in Moscow. Machines, he feels, will even work out comprehensive theories, based on experimental data.

Midwest lags in electronics

Graduate training (at least a year) is essential and a Ph.D. is desirable for engineers who want to play an important part in electronics, says Dr. Frederick E. Terman, provost of Stanford University. Companies that lack interest in the man with the Ph.D. are destined to become the "peon group" of the electronics industry. A case in point, says Dr. Terman, is the Midwest, which is more concerned with profits from established activities than with developing new products. As a result, it has failed to show the explosive expansion demonstrated by the industry on the West Coast and in New England.

profit-making eggheads

A team of top nuclear experts is helping dispel the idea that scientists are "eggheads" without business sense. As Dr. Zalman M. Shapiro, president, Nuclear Materials and Equipment Corp., Apollo, Pa., sees it: "Business is no particular mystery . . . it's just common sense." To prove it, NUMEC, formed by three top scientists from Westinghouse and GE, is doing very well in the business world. In fact, says Dr. Shapiro, there's no reason why NUMEC can't become the Du Pont of the atomic-fuel industry.

European computers close the gap

American industry pays too little attention to European computer developments, says Isaac L. Auerbach, president, Auerbach Electronics Corp. Developments from across the ocean are vital to U. S. information-processing techniques. In Switzerland, hydraulic-logic experiments are as advanced as our own. In Germany, pattern-recognition work (the key to computer "learning") is outstanding. In England, a major difficulty in the production of uniform thin-film magnetic memories has been overcome. If the U. S. is to retain leadership in this important field, it must keep abreast of significant activity elsewhere, says Auerbach.

gas-bag sentinels

Detection of unannounced satellites may be the job of high-altitude balloons carrying optical systems for all-sky surveillance. Electro-Optical Systems Inc., Pasadena, Calif., emphasizes that the proposed system is more than just another tracking device—the 20-mile high balloons will actually pick out satellites on which there is no available tracking information. They have the further advantage (over satellite-borne trackers) of being able to return to earth for maintenance.

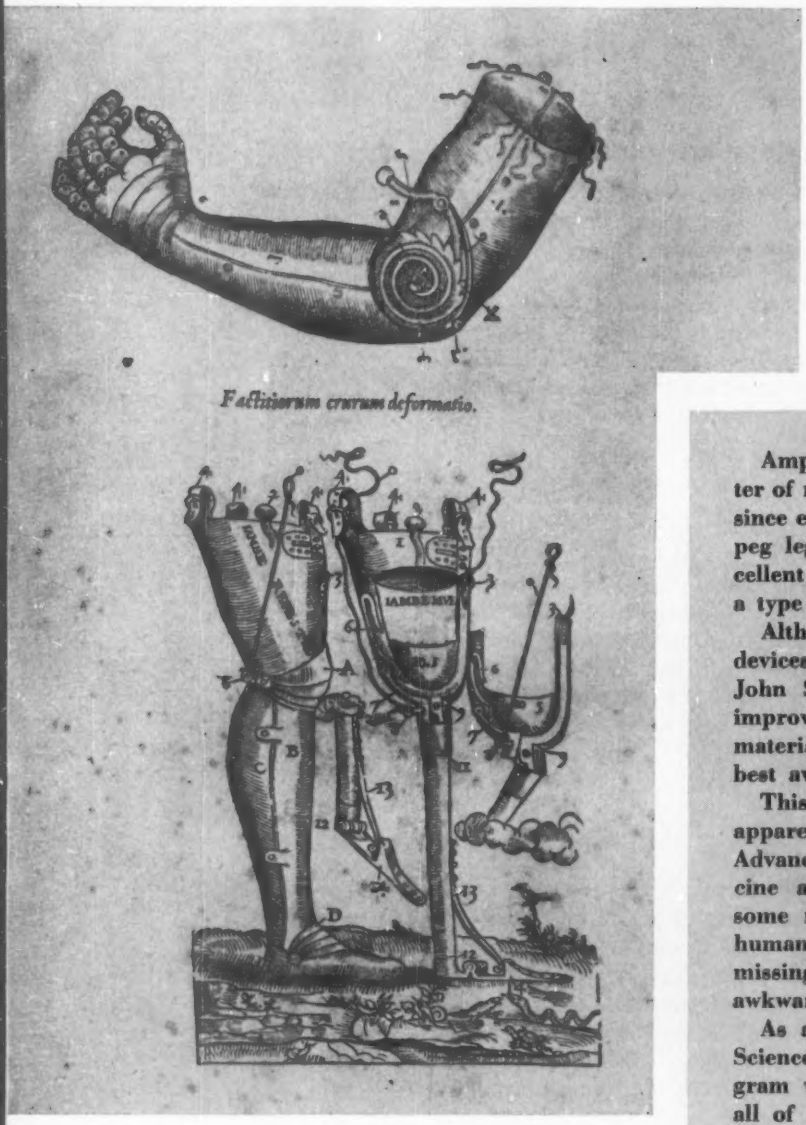
more on gobbledygook

Until the public has a better idea of what engineers are talking about, it will not support them or their projects, says Frank A. Butrico, chief, engineering-resources program, Public Health Services. Lack of ability to "write down" to the layman is one of the engineer's greatest shortcomings. Engineering jargon is well suited to technical meetings, but it fails dismally when used for communicating with the public. "Maybe we do it to impress people, but we certainly do not influence them," Mr. Butrico declares.

degree in red-tape cutting

Analysis and research on government contracts will be the subject of a new program offered at George Washington University. Organized under the university's Graduate School of Public Law, the curriculum will provide both degree and short courses for employees of industry and government. A complete library of pertinent reference material has been accumulated, and a new periodical will be published as part of the program. Fellowships for students wishing to specialize in government contracts will be available.

Human Engineering:



Factitiorum crurum deformatio.

Amputation of the extremities as a matter of medical necessity has been practiced since earliest recorded times. The familiar peg leg of Long John Silver was an excellent example of a prosthesis adapted to a type of surgery popular in 1600.

Although newer and more functional devices have gradually been developed, John Silver's wooden replacement, with improvements in methods of fitting and materials, has continued to be one of the best available substitutes for a lost limb.

This lack of progress became acutely apparent at the close of World War II. Advancements in all other fields of medicine and surgery were responsible for some remarkable feats in the repair of human bodies. But the veteran with a missing limb still faced the handicap of an awkward Sixteenth Century appliance.

As a result, the National Academy of Sciences initiated a broad research program which, for the first time, brought all of the medical disciplines to bear on the problem. Studies of normal human locomotion were started at the University of California with both the School of Medicine and the Engineering College participating. These studies provided some much-needed quantitative data on displacements, forces and moments, phase action of muscle groups, and related phenomena.

Translation of this research into workable hardware has been largely an engineering job, and has resulted in some of the remarkable new mechanisms illustrated on these pages.

C. W. RADCLIFFE
Associate Professor
Mechanical Engineering
University of California
Berkeley, Calif.

mechanisms for amputees

THE human leg and foot provide a firm base of contact with the ground by means of a highly complex and efficient system of articulated segments (linkage mechanisms) and muscles (power sources), under the control of the nervous system (an exceptional computer).

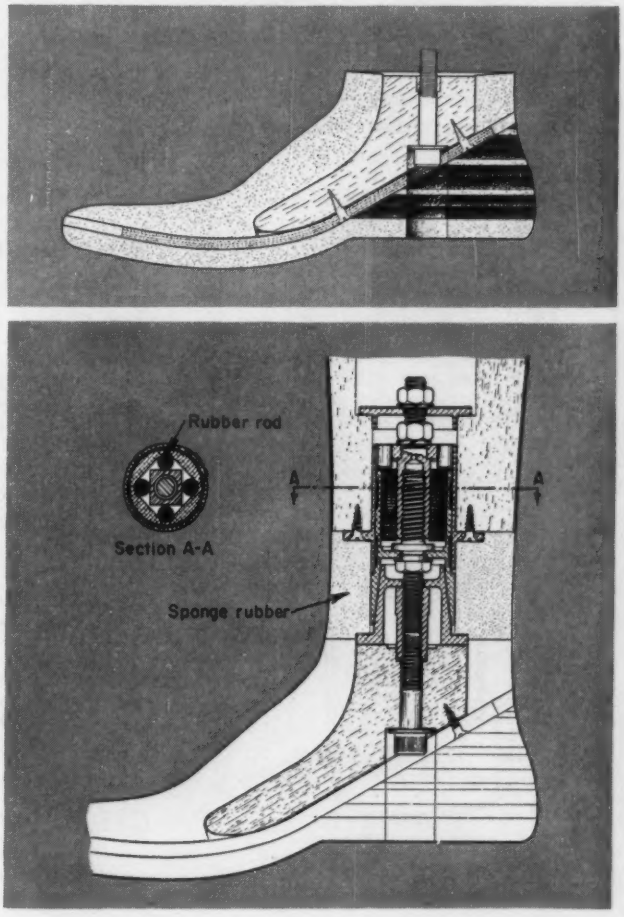
In the artificial leg, articulation and, to some extent, muscle power can be simulated. The big problem is to make the device work without the sophisticated control normally supplied by the brain.

No-Shock Feet

In normal human locomotion, the center of gravity of the body progresses through space with minimum variation in velocity, keeping energy demands at a minimum. Any changes in velocity, whether in magnitude or in direction, will be accompanied by muscle work, and hence fatigue. A change in elevation of the center of gravity will also increase muscular effort. The center of gravity normally follows a path which, when projected onto a vertical plane parallel to the direction of progression, approximates a sinusoidal curve. The peak-to-valley amplitude of this motion is approximately 1 in.

One of the major functions of the ankle joint is to help absorb the shock of the heel striking the ground and to maintain the smooth sinusoidal path of the center of gravity. Ordinarily, the knee joint also contributes to this function by controlled bending. But because of buckling tendencies—insecurity at the knee due to loss of normal muscle action—it has not been possible in any known prosthetic knee to provide for shock absorption by controlled knee flexion. Thus, all shock must be absorbed by the prosthetic ankle joint.

The foot design shown in Fig. 1, developed at the University of California, has had wide acceptance by amputees. It is an excellent example



1 **Shock absorption** is assumed by a wedge of rubber-like sponge material in the heel of the U-C designed foot (above). Elastic material not only absorbs the shock of the initial loading of the prosthesis at heel contact, but also provides an extremely lifelike simulation of normal ankle action without use of an articulated joint. Contoured surface of support on the cantilevered "keel" provides for a smooth roll-over and push-off on the prosthesis.

Further refinement has been accomplished on this foot, following studies of relative rotations between the various leg bones. During the weight-bearing, or stance, phase of walking, there is considerable relative rotation between the pelvis and foot about the long axis of the leg. This twisting motion may exceed 20 degrees in some normal persons and is accompanied by a torque about the long axis of the leg which may reach 75 lb-in. The device shown (below), installed in the ankle of the prosthesis, provides a means of absorbing the twist. It is designed with a torsional spring constant of approximately 2 lb-in. per deg. The "square-within-a-square" design of the torsion spring has been the most successful of many different designs for elastic-restoring mechanisms.

of design based on functional needs, rather than on duplication of the normal anatomic structure.

Knees with Stability

There are two, almost completely separate, functions that prosthetic knee mechanisms must provide: 1. Stability against sudden buckling of the knee joint during the stance phase. 2. Simulation of the controlling action of the knee muscles during the swing phase.

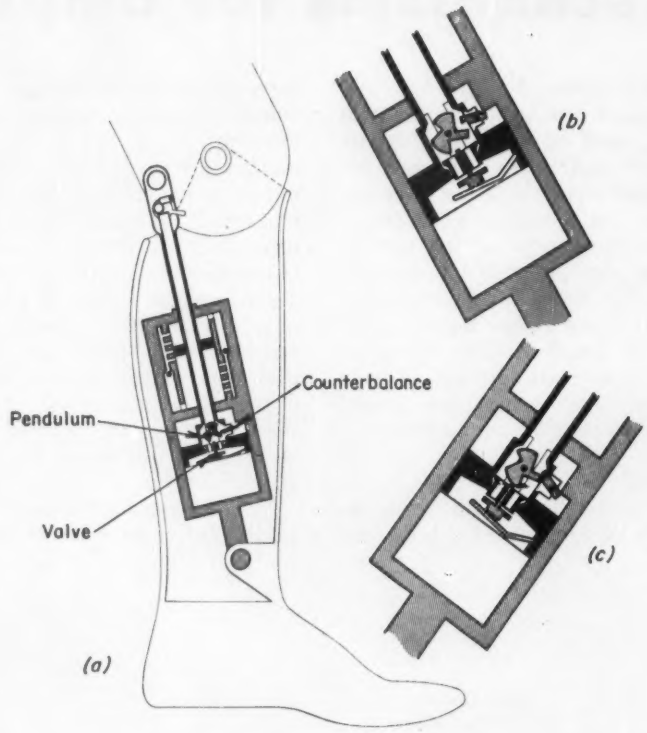
Knee stability can be provided in three basic ways: 1. Alignment of joints. 2. Use of brakes or locking devices. 3. Mechanisms which allow the amputee to use stump action to control the knee.

Brake mechanisms are a logical means of increasing stability at heel contact while allowing a release of braking action prior to push-off. Many mechanical and hydraulic devices have been developed, one of the most interesting being the Mauch "pendulum" control. This ingenious device is designed to provide a braking action to resist bending at the knee any time that the extension motion of the knee is interrupted, as in stumbling, Fig. 2.

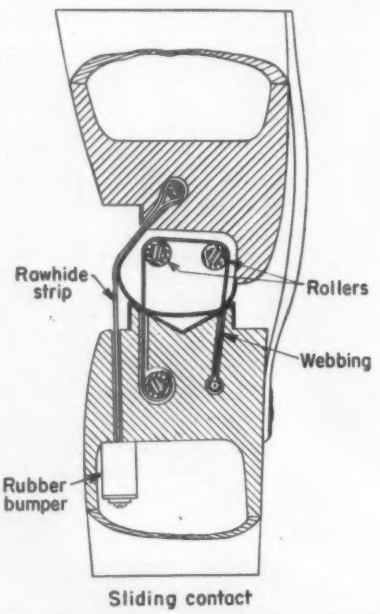
Polycentric mechanisms, as alternatives to brake mechanisms, are

2 Knee brake, designed by Mauch, consists of a hydraulic cylinder brake actuated by pendulum control.

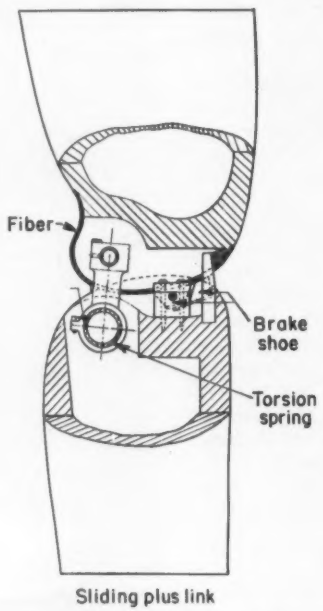
Any unbalance causes the counterbalance to rotate counterclockwise and make contact with the projecting arm on the pendulum, Fig. 5*a*. This maintains the pendulum in a position of maximum clockwise rotation, allowing the valve to act as a simple check



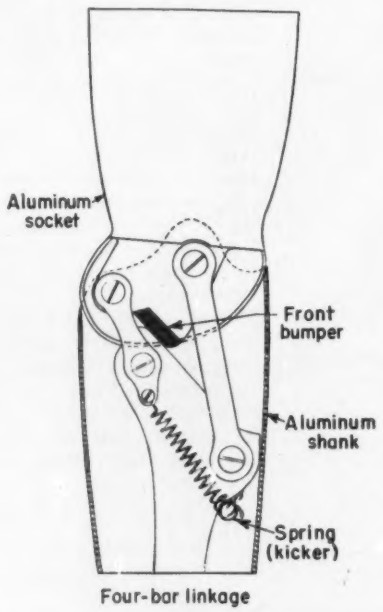
3 *European Polycentric Knee Mechanisms*



Sliding contact



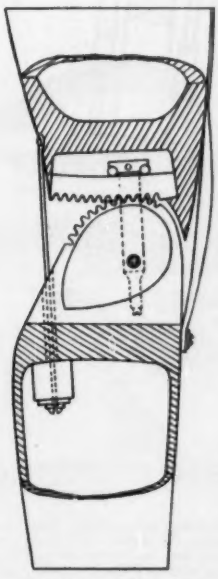
Sliding plus link



Four-bar linkage

valve. The valve permits knee extension but closes upon knee flexion. At the instant of heel contact, as the knee reaches a position of full extension, the counterbalance makes contact with a shoulder in the cylinder and rotates into the position shown in Fig. 5*b*. The pendulum immediately begins to swing counterclockwise under the action of gravity and the inertia forces associated with the deceleration of the prosthesis at this time.

After a time interval of approximately 0.1 sec, the pendulum has rotated into the position shown in Fig. 5c. In this position the pendulum blocks any tendency for the valve to close; therefore, the knee is free to flex at the beginning of the next swing phase. Any sudden tendency for the knee to buckle at heel contact would be braked by the valve if it occurred within the 0.1 sec interval required for the pendulum to complete its rotation. After this delay period, the knee is free to flex. As knee flexion begins, the check valve is forced against the pendulum and holds it in the position shown in Fig. 5c as long as flexion continues uninterrupted. When knee motion changes from flexion to extension, the pendulum is released and rotates clockwise under the action of the counterbalance and the cycle then repeats.



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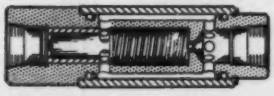

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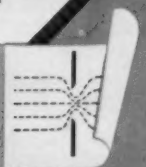

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used for several reasons:

- Increase the mechanical advantage of the amputee's stump in controlling knee motion in the weight-bearing phase.
- Prevent scuffing of the toe in the swing phase by adding an upward translation component to the shank-thigh motion during knee flexion.

The polycentric action can be created by (1) rolling or sliding (or both) of two mating curved surfaces; (2) combination of linkage and sliding contact; (3) a four-bar linkage, Fig. 3.

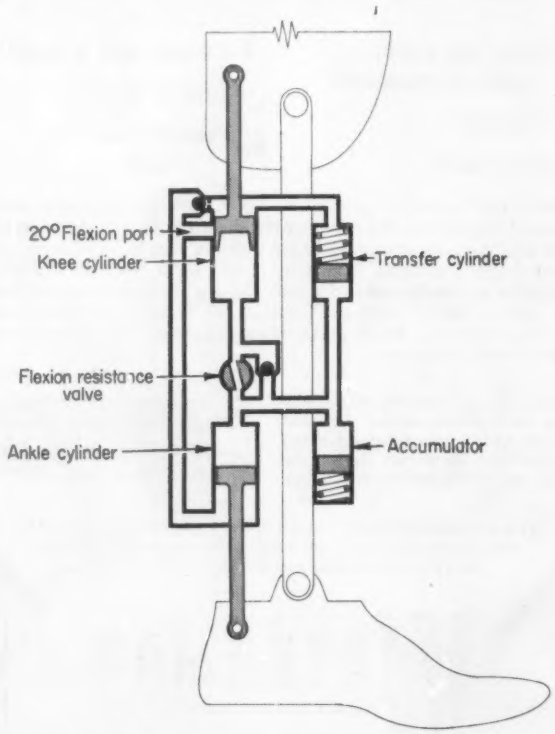
Swing Control

In recent years, both designers of prosthetic devices and amputees have discovered that a proper control of the relative motion at the knee in the swing phase is of major importance. Previously, knee stability was of primary concern and swing control added as an afterthought. Modern methods of fitting and alignment have improved the stability of the above-knee prosthesis to the point where, at the present time, swing-control devices are of considerable interest, Fig. 4, 5.

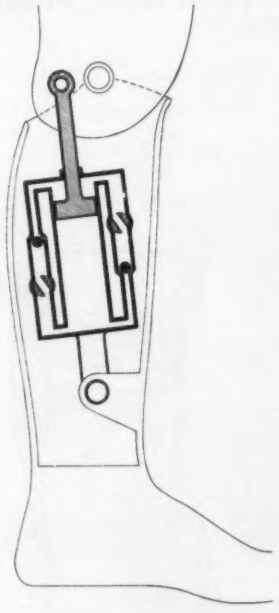
4 **Hydraulic coordination** of knee and ankle provides swing control in the Stewart knee.

As the knee flexes at the beginning of the swing phase, the knee piston moves downward. Oil is forced through the needle valve which provides resistance similar to quadriceps action to begin the forward acceleration of the shank. Since there is no oil exit available from the ankle cylinder, it does not move at this time. Oil under the knee piston is forced into the transfer cylinder and from the above transfer piston, back in above the knee piston. The differential volume of the knee piston rod results in an extension bias due to the pressure increase in the accumulator. After 20 degrees knee flexion, the port is uncovered which allows the pressure in the transfer cylinder to force the ankle piston downward which lifts the toe as a result of dorsiflexion of the ankle. Further knee flexion results in additional ankle flexion through the direct hydraulic coupling. Flexion resistance is adjustable by the needle valve.

As the leg swings forward, the knee begins to extend and oil moves from above the knee piston to the underside of the angle piston through the fixed-orifice, check-valve combination. As the knee again reaches the fully extended position, the foot has repositioned itself ready for the stance phase.

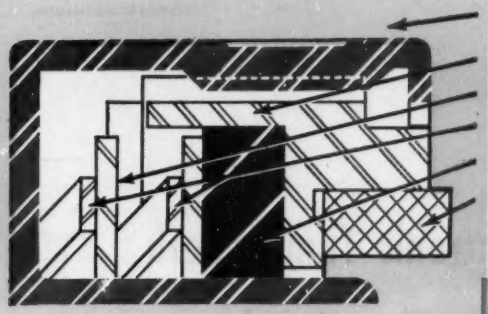


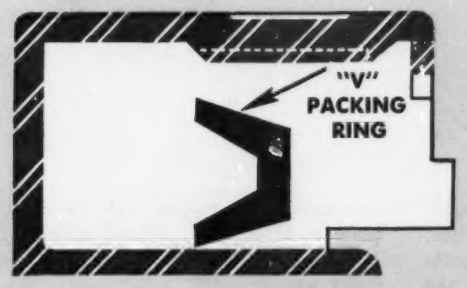
5 **Leakage and manufacturing problems** associated with hydraulic mechanisms led the Prosthetics Design Group at the University of California to develop a pneumatic swing-control unit. Required forced-displacement relationship is obtained from the pressure volume characteristic of the enclosed air volume. An adjustable leak in each direction allows a modification of the force-displacement characteristics and provides energy dissipation for pneumatic damping of the motions.



ACKNOWLEDGMENT: This article is based on a paper presented at the Sixth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 10-11, 1960.

GITS HH-TYPE SEAL SERIES





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All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

Circle 415 on Page 19

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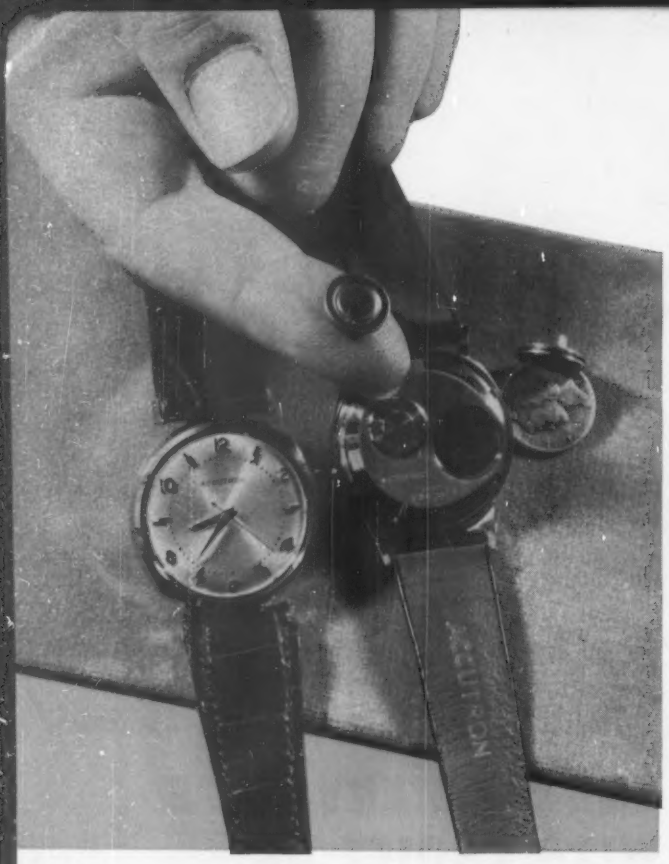


Electronic Tuning Fork Beats Time for Accuracy

New watch has hands to tell time like any other—but there the similarity ends. It lacks a winding and setting stem, has no "tick," and keeps time as well on a journey to the moon as it does on earth.

NEW YORK—A miniature tuning fork, driven and controlled by a transistorized electronic circuit, is the precise heart of a rugged new battery-powered wristwatch. Because there is neither balance wheel nor hairspring, the familiar tick-tick has been replaced by the barely audible hum of the tuning fork.

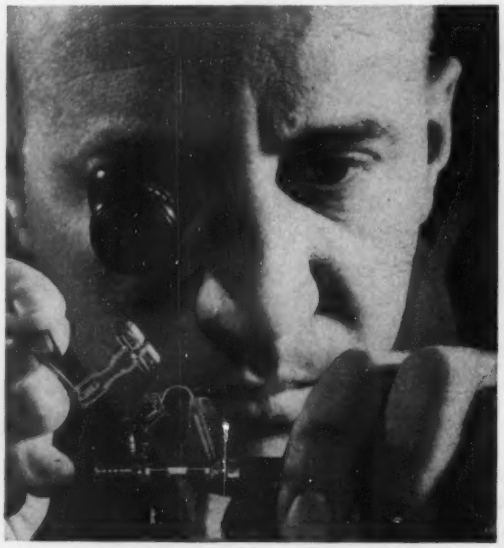
Accuracy of Bulova's new Accutron—which is guaranteed to gain or lose no more than one minute per month—has been amply demonstrated by its first use. The 8-oz Accutron movement is presently doing the work of some 30 lb of conventional timers aboard Explorer VII, turning off the satellite's transmitter at a preset time.

Accutron has no winding and setting stem. The hand-setting mechanism is engaged when a recessed handle on the back of the case is lifted into "setting position." There is no possibility of leakage through this mechanism, so the watch is far more dust and waterproof than most "waterproof" watches. Bulova also says its watch is virtually wearproof—it has only 12 moving parts, and no make-and-break contacts.

Vibration is converted to rotary motion for the hands through a tiny index wheel. Measuring only 0.095 in. in diameter, the wheel has 300 precisely machined teeth. Details on the manufacture of the tiny gear have not been released.

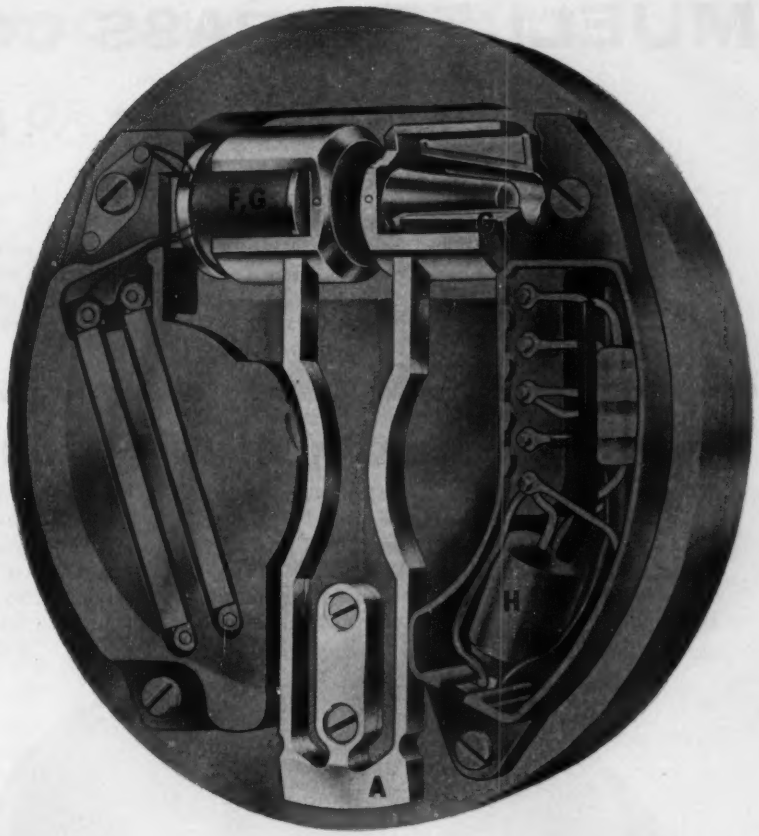
Because of the shape of the index-wheel teeth and the "draw" effect of the index-finger motion, the watch is virtually immune to shock and vibration. External disturbances can cause the tuning fork to vibrate at three times normal amplitude without affecting motion of the index wheel.

Electromagnetic coils that perpetuate fork vibration are $\frac{1}{4}$ in. long, have 8000 turns of 0.0006 in. diam wire. Drawing 8 microwatts from a 1.3 v. mercury battery, coils generate 360 pulses every second.

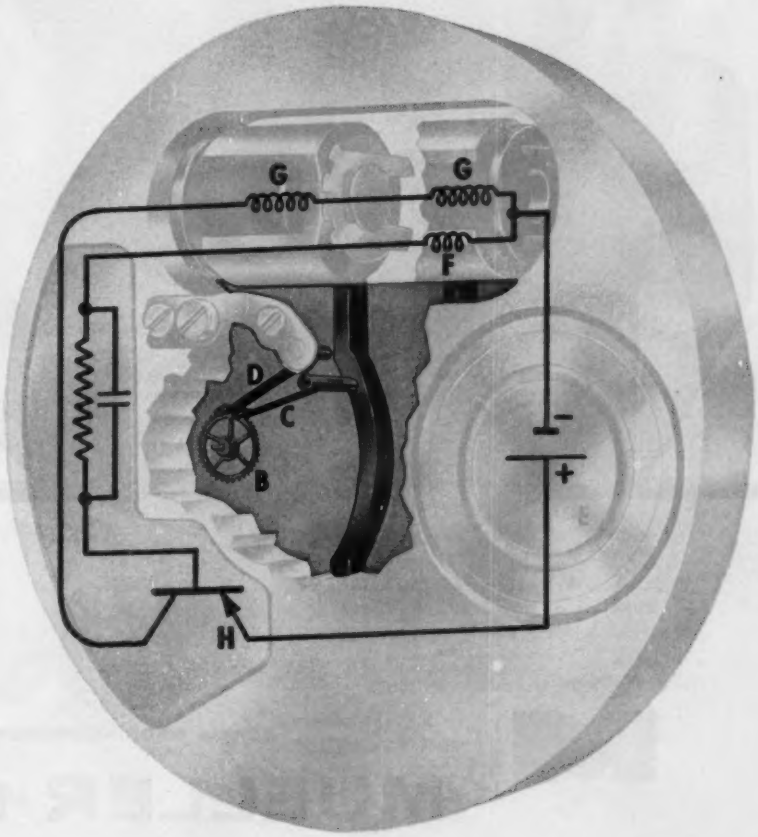


Swiss horologist and physicist Max Hetzel, who invented the unique movement, inserts tuning fork into position between coils in the plastic-encased modular circuitry of the Accutron watch. Mr. Hetzel first revealed the idea behind the watch in a treatise on electromechanical filters that won the silver medal of the Technische Hochschule E.T.H. of Zurich, Switzerland. He is now chief physicist, Bulova Watch Co. Inc.

Accurate time base for the new watch is a 1-in. tuning fork driven at natural frequency by a pulse-powered solenoid circuit. Vibration amplitude is measured by a phase-sensing coil. On each excursion, induced current in the coil charges a capacitor through the secondary transistor circuit. When the base circuit becomes momentarily conducting a pulse is fed through solenoid drive coils. If the tine moves too far, phase-sensing coil current overrides battery current, so that less power is delivered to the solenoid. The circuit is so designed that a 10 per cent increase in tine amplitude reduces drive current to zero. Conversely, a 10 per cent decrease in amplitude doubles the drive current.



A Tuning fork
B Index wheel
C Indexing finger
D Pawl finger
E Battery
F Phase-sensing coil
G Drive coils
H Transistor



Almost unbelievable microminiaturization is required to convert a tuning fork into a serviceable watch. A transistorized circuit delivers a pulse of current of controlled amplitude 360 times a second to maintain the fork's vibrations. Converting vibrations to a readable time indication is accomplished by a minute index wheel and pawl system. As the fork vibrates, a jewel-tipped spring (the indexing finger) moves back and forth, advancing the index wheel one tooth for each fork cycle. The index wheel, in turn, drives the watch hands through a short gear train. A second jewel-tipped spring (the pawl finger) restrains contrarotation of the index wheel during the return stroke of the index finger.

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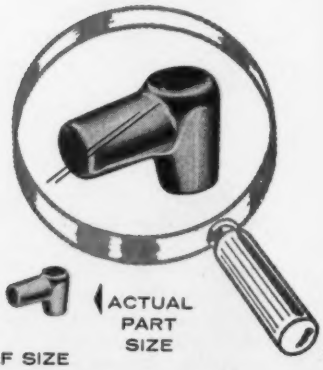
BRASS, BRONZE, ALUMINUM FORGINGS

The two parts shown here dramatically illustrate the ability of the Mueller Brass Co. to produce precision forgings regardless of size or configuration. Both the tiny dental drill nozzle and the big heat exchanger shell hub, which is the largest of its kind ever produced, were forged to exacting specifications. The weight of the nozzle is only a few ounces while the shell hub weighs 40 lbs., and has a forged pocket 7 13/16" in diameter and 4 3/16" deep. By way of size comparison, the pocket is big enough to hold over 14,000 of these tiny drill nozzles. By forging the pocket, considerable machining time and money was saved. The sound, dense structure of the shell hub makes it ideal for the high pressure application for which it was designed. The forging not only does the job better, but was produced for 25% less than the casting it replaced. Experience makes it possible for the Mueller Brass Co. to produce high quality precision forgings regardless of specifications . . . why not put this experience to work for you?



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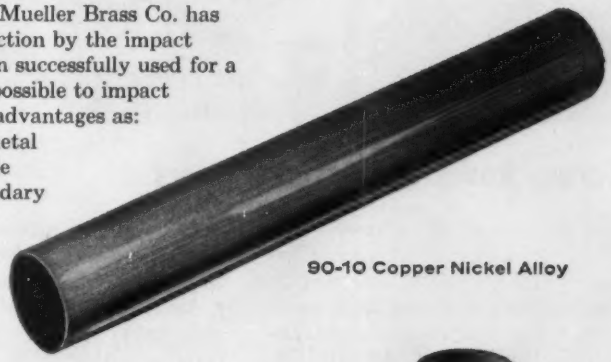
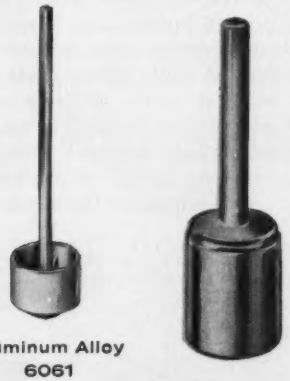
The parts shown here are representative of the group now being economically produced as impact extrusions by the Mueller Brass Co. who offer complete engineering and design service in the development of new parts from copper base alloys.

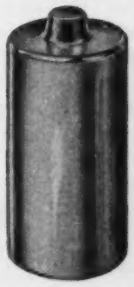


90-10 Copper Nickel Alloy



Aluminum Alloy 6061

Oxygen Free High Conductivity Copper



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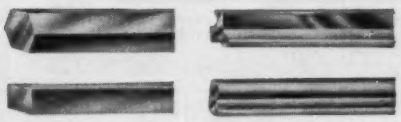

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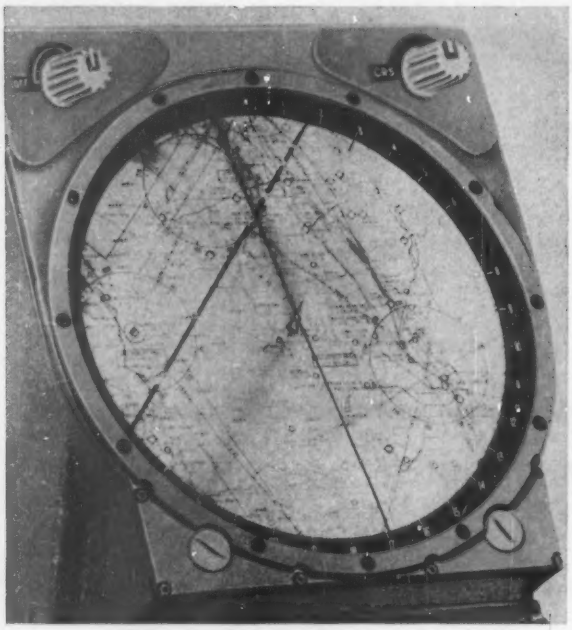
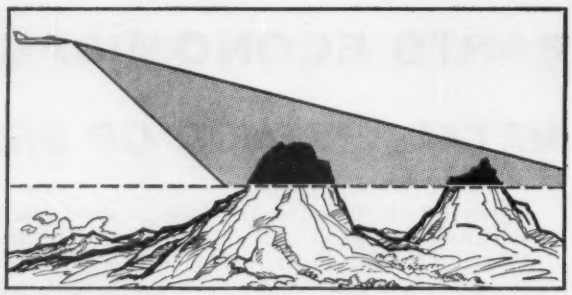




Taran includes a moving-map display that shows a pilot his position and heading at all times (left). Symbol at center of screen, representing the aircraft, rotates to conform with the flight direction; map moves beneath the symbol to indicate travel direction. Second feature of the Taran system is a radar that "slices off" hilltops (above). By setting the radar to ignore everything below a given altitude, the pilot can keep his data-display screen uncluttered with superfluous information, can even fly hedge-hopping missions in bad weather or at night.

Taran: Radar for Hedge Hoppers

CULVER CITY, CALIF.—Newest electronic system for attack aircraft lets fighter-bombers avoid detection by darting below an enemy radar cover, even in bad weather or at night. Developed by Hughes Aircraft Co., Taran (Tactical Attack Radar and Navigator) also assists the pilot in attacking surface targets with precision, engaging hostile aircraft, and conducting reconnaissance.

The system has three basic capabilities:

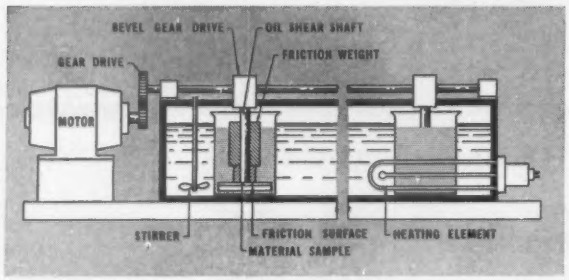
- Navigation—It automatically navigates to and from a target in any kind of weather.
- Air-to-ground attack—New high-resolution radar picks out ground targets even through dense fog.
- Air-to-air attack—It searches for and tracks enemy aircraft and launches either radar or infrared-guided missiles.

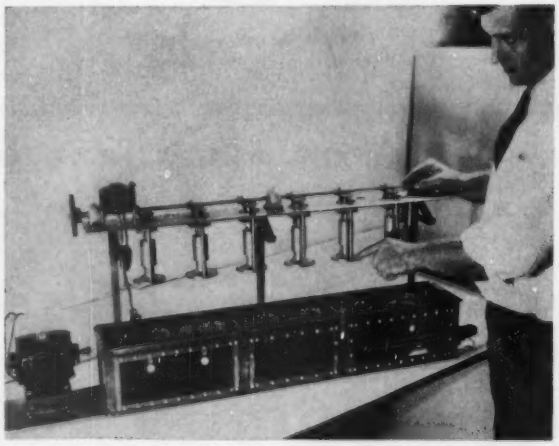
When in the "terrain-avoidance" mode, the radar "sees" only those objects that are high enough to be dangerous. The pilot, able to select any cut-off altitude he chooses, can easily avoid tall obstacles because his radarscope is not cluttered with unimportant objects.

"Ground mapping" is another feature designed to aid blind flying. In this mode, the radarscope displays a picture of the terrain below so that the pilot can compare the picture with his navigation map.

Navigation to the target is aided by a moving-map display and an inertial navigator which computes aircraft position and heading. The map display, prepared on photographic slides from standard aeronautical charts, is projected on a ground-glass screen. The map moves during flight so that it always shows the area below. A symbol in the center represents the airplane.

Oil Tester Sets Up "Real" Conditions





Pemoot (Permawick Electric Motor Oil Oxidation Tester) controls oil shearing, heat, ambient conditions, and metal-wear debris while simultaneously testing six lubricants. Friction weights rub against bearing metals (mounted on top of the flat plates); heat-transfer fluid surrounds each beaker. Pemoot was developed by Permawick Co., Detroit.

Bruning Neoglide Drafters. Speed drafting up to 35%! Unique design gives complete maneuverability on any board *at any angle* without adjustment. Counterweight provides "floating" action. Touch-control protractor speeds angle selection.

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P5

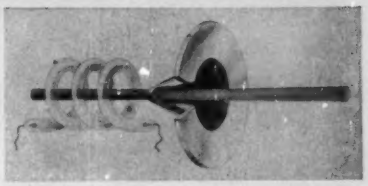
Maser Promises Optical Communications

NEW YORK—Light has been used successfully as a means of long-distance communication by scientists at Bell Telephone Laboratories. In experiments conducted earlier this month, a ruby optical maser was set up at Bell Laboratories in Holmdel, N. J.; its narrow, intense beam of light was directed at the Murray Hill, N. J. laboratories, twenty-five miles away. The red flashes were clearly visible by naked eye and registered on photomultiplier tubes.

Coherence of the light generated by the optical maser is its most novel property and the key to its use in communications. It is coherence of radio waves, for example, that enables them to be modulated, amplified, and detected by telegraph, telephone, and television. By providing a source of coherent light, the maser indicates the possibility of extending present communication technology to the optical frequencies.

Bell scientists have also conducted experiments in which the pulses of light have been transmitted along a quarter mile of 2-in. diameter circular waveguide where the dust and fog of the atmosphere would not attentuate the light beam. Photomultiplier tubes at the waveguide end recorded clear pulses of high-intensity light.

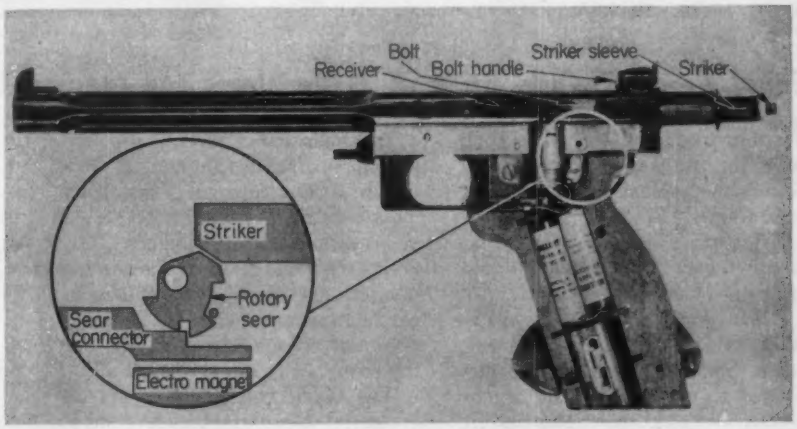
At the present time, according to Bell scientist W. S. Boyle, messages can be sent only in a code based on repeated flashes. However, the fact that the coherent light is emitted in short bursts rather than as a smooth pulse shows that it may eventually be possible to modulate the signal so that many telephone conversations or television signals can be transmitted simultaneously.



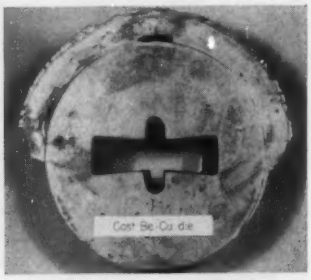
Heart of the BTL optical maser is a synthetic ruby rod, 1.5 in. long and 0.2 in. in diameter (right). The two ends are polished until extremely flat and parallel, then covered with a reflecting layer of silver thin enough to be slightly transparent. The rod, mounted in the center of a spiral photoflash lamp, is illuminated with an intense flash of ordinary white light. When power applied to the flash lamp exceeds a certain value, a nearly parallel beam of light is emitted through the silvered ends of the rod. This light is red, like the ordinary fluorescent light from ruby, but differs from it in several important ways: It is sixty times closer to being monochromatic than the ordinary fluorescent light from ruby; it is coherent, or of single phase; and it is emitted within a cone angle of only 0.1 degree.

Hair-raising Hairtriggers Made Safer

Even a change in temperature has caused hair-triggered competition pistols to discharge—and their unpredictable nature has caused many qualified shooters to abandon the sport. A new trigger mechanism, designed by High Standard Mfg. Corp., Hamden, Conn., though it fires with a minute pressure, won't discharge accidentally when the gun is shaken or dropped. Pulling the trigger closes an electrical contact that activates an electromagnet. This, in turn, attracts the sear connector, and its movement allows the sear to rotate under pressure from the spring-driven striker. Close tolerances between the sear connector and sear, manufactured by the Carpenter Steel Co., Reading, Pa., keep gun disturbances to a minimum.



Quick Cast Keeps Tough Metals Tough



Precision-cast dies form high-strength metals in five minutes with a new process; other methods require as much as eight hours. Research engineer (left) removes a manganese-titanium alloy part from a die press operating at 1000 F. Basis of the method is the use of beryllium-copper dies (below, right) and universal heated die-holders (below, left).

FARMINGDALE, N. Y.—A die press weighing less than a ton replaces 750 tons of hydraulic press in shaping rugged "wonder" alloys by an advanced technique. Shaping time for some parts, says Republic Aviation Corp., is cut from eight hours for conventional methods to five minutes for the new technique.

First step in the process is precision casting dies from special beryllium-copper alloy in close-tolerance ceramic molds. The cast dies, which require little or no surface finishing, are then used in the die press. The company claims the new technique ends industry's search for hot-tooling material that will retain strength and mechanical properties at extremely high temperatures.

The company has also designed a heated die-holder that will maintain the constant temperature necessary for shaping these metals. Molybdenum, titanium, magnesium, and aluminum alloys that cannot be satisfactorily formed at room temperature often lose mechanical strength at operational temperatures when formed by present "hot-forming" techniques.

Previously, the solution to the problem has been costly and time-consuming heat-treating. With the Be-Cu die press, tooling savings are reported to be better than 50 per cent; time saving is enormous, and products produced by the new method are more reliable.

Signal Corps Rounds Up R & D Problems for Industry

WASHINGTON, D. C.—A guide book aimed at private industry spells out major problem areas in communications, electronic equipment, and systems. The Signal Corps has published it in both confidential and unclassified versions.

The volume, "U.S. Army Research and Development Problems Guide, Signal Corps," will be distributed to qualified private organizations through the Commanding Officer, U.S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey.

To obtain either version, a policy agreement for distribution of Research & Development Documents must be signed, acceptable evidence of a research and development capability be presented, and interested organizations must show a desire to conduct research and development effort in consonance with that of the Army.

The Guide contains chapters on command communications, combat surveillance, air navigation and traffic regulation, electronic warfare, component parts, and supporting research. Each chapter acquaints the user with the general problems related to a particular communications-electronics area. Typical of the developments needed are:

- A technical atomic standard to provide a frequency accuracy within 10^9 in miniaturized equipment.
- HF and VHF ladder-crystal filters in the range from below 1 mc to the VHF range for narrow-bandwidth filters.

Specific problems vary from unclassified to those involving confidential information.

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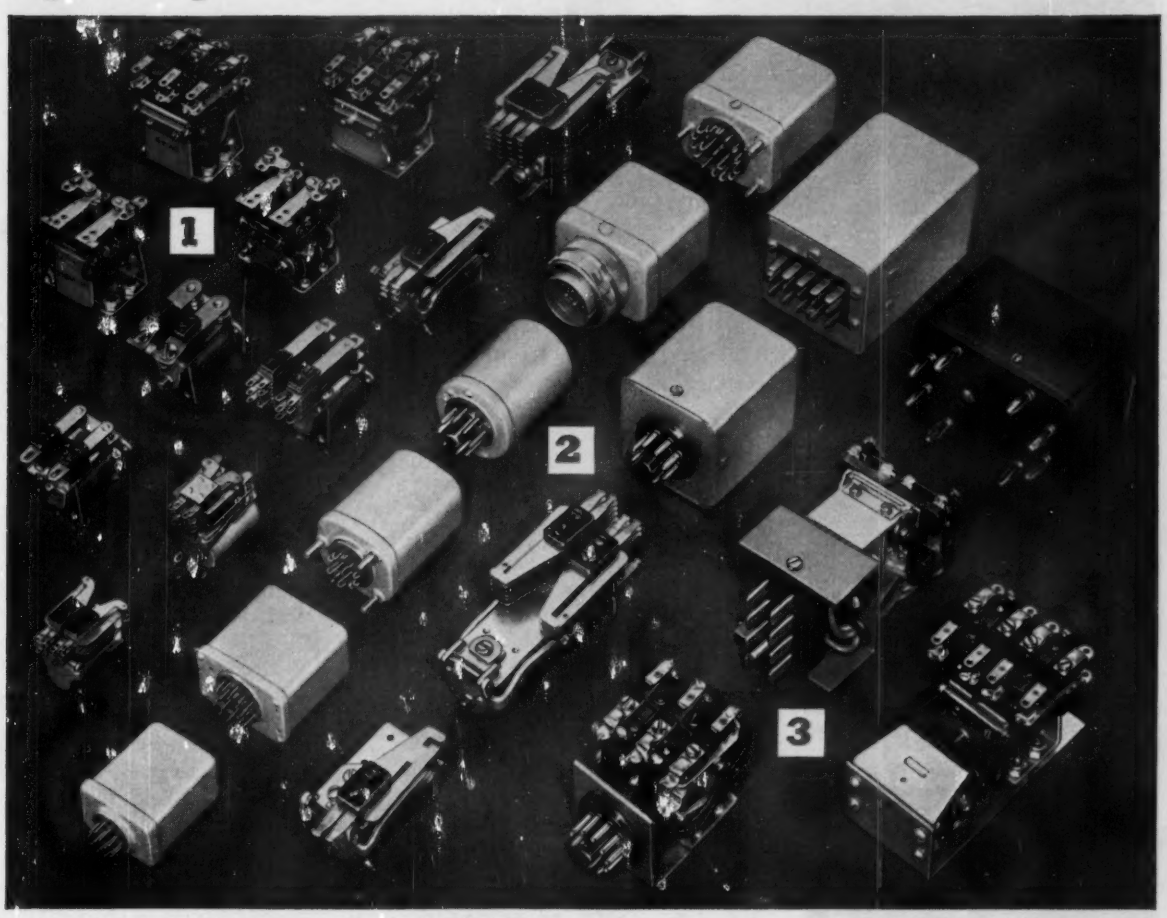


1. Eleven Standard Models **2. Typical Relay Enclosures** **3. Relays with Special Construction**

EXCLUSIVE! Contact Combinations on New Ohmite Relays Are MOLDED*

Permanence and ease of adjustment of the individual contact springs are the result of a revolutionary, new innovation found in two new Ohmite Relays—Models TT and TS. This innovation is the unique "Molded Module"* contact spring construction. The "module" is a standard, single-pole, double-throw spring combination molded into a single compact assembly. As many as six modules can be incorporated into a relay. *(*Pat. Applied For*)

QUALITY CONSTRUCTION— All Ohmite relays embody the same meticulous engineering, strict quality control, and generous use of high quality materials which have made Ohmite components the standard of the industry. Parts are plated where necessary for corrosion resistance. Springs are of nickel-silver or phosphor-bronze. Contacts are fine silver. Special contact materials, such as silver, tungsten, palladium, or gold alloy, can be supplied. Protection against humidity and moisture is paramount and is accomplished in layer-wound coils, through complete sealing with cellulose-acetate. Relays are available in a wide range of coil operating voltages and contact combinations in both AC and DC types.

65 TYPES IN FOUR STOCK MODELS— For fast service, four models in the Ohmite relay line are carried in stock in 65 types at the factory, and by Ohmite Distributors from coast to coast.

HERMETICALLY SEALED AND DUST-TIGHT RELAYS—You can specify many of the basic Ohmite relays in nonremovable, hermetically sealed enclosures for applications requiring complete relay protection. These high-quality relays are sealed in seamless steel enclosures which are exhausted and filled with dry, inert gas under control of Ohmite engineers. Ohmite hermetically sealed relays are available with either plug-in or solder terminals. Relays are also made with nonremovable dust-tight covers and removable dust covers.

RELAYS WITH SPECIAL CONSTRUCTION—Ohmite relays are available with special terminals or special construction, such as relays with push-on or screw terminals, relays with binding-post terminals. Where quantities warrant, Ohmite will manufacture relays made to your specifications. Ohmite can furnish not only special terminals, special contact combinations, contact materials, and coils but also special enclosures, connectors, impregnation, or frames. Ohmite relays can be engineered to meet your special pull-in, drop-out, or time-delay requirements.

For your special or unusual relay applications, let Ohmite's experienced engineers help you work out the best solution.

Write on company letterhead for Catalog and Engineering Manual 58.

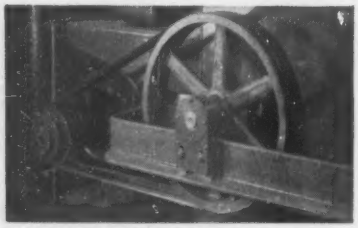
OHMITE

OHMITE MANUFACTURING COMPANY
3618 Howard Street,
Skokie, Illinois

RESISTORS RELAYS TAP SWITCHES
RHEOSTATS TANTALUM CAPACITORS
R.F. CHOKES VARIABLE TRANSFORMERS
DIODES

Circle 419 on Page 19

WOOD'S POWER TRANSMISSION PRODUCT NEWS



NEW, NON-FREEZING VARIABLE

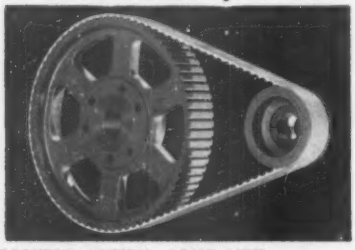
Wood's new "SVS" stationary control, variable speed drive has positive locking collars and other, patented features which eliminate freezing, assure easy speed change. No lubrication is required. Uses standard v-belts and stock companion sheaves. Write for Bulletin 6102.

Circle 420 on Page 19

NEW, TREMENDOUS SAVINGS

Wood's new Ultra-V Drives handle up to 3 times more horsepower than conventional v-belt drives in a given space . . . reduce overall drive dimensions as much as 50% . . . cut weight up to 25% and costs up to 30%. Write for Bulletin 9102.

Circle 421 on Page 19



POSITIVE ACTION—LONG LIFE

Wood's Timing Belt Drives provide positive, slip-free action. Belts are all muscle. No high initial tension, tension devices or lubrication needed. Drives are light weight, compact . . . quiet and clean. Wide load and speed range. Equipped with famous Sure-Grip Bushings. Write for Bulletin 2100.

Circle 422 on Page 19

MP/360B

Woods

T. B. WOOD'S SONS COMPANY

CHAMBERSBURG, PENNSYLVANIA

ATLANTA • CAMBRIDGE • CHICAGO
CLEVELAND • DALLAS

Meetings and Shows

Nov. 2-4—

Society of Automotive Engineers Inc. National Fuels and Lubricants Meeting to be held at The Mayo, Tulsa, Okla. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Nov. 8-11—

Society of Die Casting Engineers. First National Die Casting Exposition and Congress to be held in the Artillery Armory, Detroit. Additional information can be obtained from the society, 19382 James Couzens Highway, Detroit 35, Mich.

Nov. 14-16—

Steel Founders' Society of America. Fifteenth Technical and Operating Conference to be held at the Carter Hotel, Cleveland. Additional information can be obtained from SFSA headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Nov. 14-17—

American Institute of Electrical Engineers - American Institute of Physics. Magnetism and Magnetic Materials Conference to be held at the Hotel New Yorker, New York. Additional information can be obtained from AIEE, 33 W. 39th St., New York 18, N. Y.

Nov. 14-18—

American Society of Tool and Manufacturing Engineers. Western Engineering Conference and Exhibit to be held at the Memorial Sports Arena, Los Angeles. Further information is available from ASTME headquarters, 10700 Puritan Ave., Detroit 38, Mich.

Nov. 15-16—

Twelfth Annual Mid-America Electronics Conference to be held at the Hotel Muehlebach, Kansas City, Mo. Further information is available from the Institute of Radio Engineers, 1 E. 79th St., New York 21, N. Y.

Nov. 16-19—

Society of Naval Architects and Marine Engineers. Annual Meeting to be held at the Waldorf-Astoria Hotel, New York. Additional information can be obtained from society headquarters, 74 Trinity Place, New York 6, N. Y.

Nov. 20-22—

Fuid Controls Institute Inc. Fall Meeting to be held at The Drake, Chicago. Additional information is available from FCI executive secretary, E. R. Rath, P. O. Box 667, Pompano Beach, Fla.

Nov. 27-Dec. 2—

American Society of Mechanical Engineers. Winter Annual Meeting to be held at the Statler Hilton Hotel, New York. Further information can be obtained from ASME, 29 W. 39th St., New York, N. Y.

Nov. 28-Dec. 2—

Twenty-fourth National Exposition of Power and Mechanical Engineering to be held at the Coliseum, New York. Additional information is available from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Nov. 30-Dec. 2—

Futuronics Exposition, sponsored by the Long Island Electronics Manufacturers Council, to be held at Roosevelt Raceway Exhibit Hall, Westbury, Long Island, New York. Further information can be obtained from Rogers & Agate Inc., 19 W. 44th St., New York 36, N. Y.

Dec. 3-6—

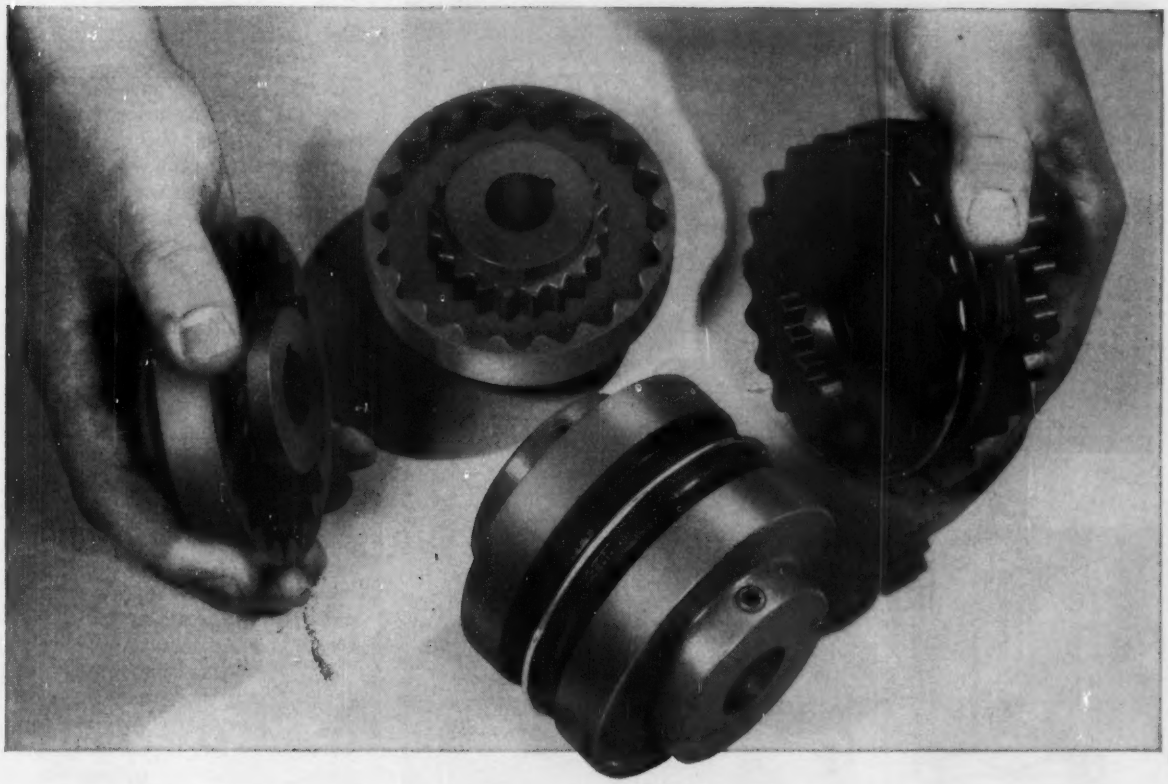
Fourth Annual International Visual Communications Congress to be held at the Hotel Sherman, Chicago. Sponsors are the American Institute for Design and Drafting and the Society of Reproduction Engineers. Additional information is available from VCC headquarters, 10600 Puritan Ave., Detroit 38, Mich.

Dec. 5-8—

American Rocket Society. Annual Meeting and Astronautical Exposition to be held at the Shoreham Hotel, Washington, D. C. Further information can be obtained from society headquarters, 500 Fifth Ave., New York 36, New York.

Dec. 5-8—

National Conference on the Application of Electrical Insulation to be held at the Conrad Hilton Hotel.



"Sure-Flex" Coupling's unique design, 4-way flex are . . .

A "SURE CURE" FOR SHOCK, VIBRATION, SHAFT MISALIGNMENT

Unique design and 4-way flexing action enable Wood's "Sure-Flex" Couplings not only to absorb all types and combinations of angular and parallel misalignment and end-float . . . but from 5 to 15 times more shock and vibration than other leading flexible couplings. There are only four basic parts which lock together without clamps or screws, tightening securely under torque to provide smooth, dependable power transmission. There is no metal-to-metal contact, no wear, no need for lubrication or maintenance. "Sure-Flex" Couplings are easily installed, unaffected by abrasives, dirt or moisture. Operation is noiseless. Get all of the facts. *Write for Bulletin 5103.*

Wood's

T. B. WOOD'S SONS COMPANY • CHAMBERSBURG, PENNSYLVANIA

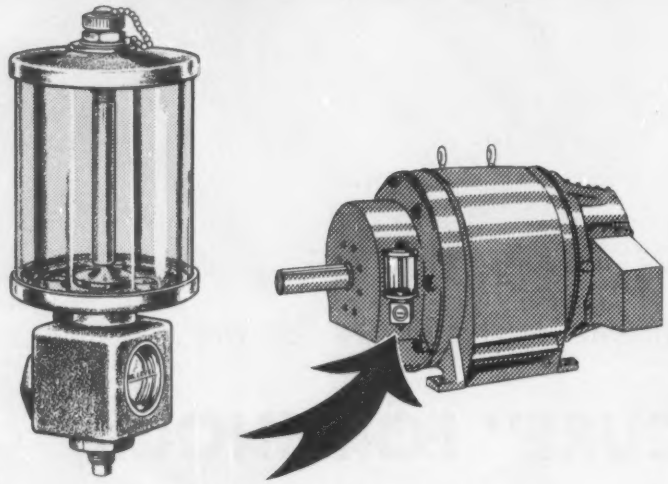
SF/160A

ATLANTA • CAMBRIDGE • CHICAGO • CLEVELAND • DALLAS

New Ideas From Oil-Rite

. . . to solve your lubrication problems

Are you looking for low cost Oilers — automatic lubricating systems — special lubricators, systems or components — *ways to reduce costs?* You will find the answer in the Oil-Rite line — complete with engineering service.



HERE'S A SAMPLE

A manufacturer of large electric motors wanted visual proof of proper oil level within a device which continuously replenishes oil as used by bearings. Oil-Rite suggested this lubricator with a large sight in base for easy visual check of oil level. It also includes a top filler cap — an exclusive Oil-Rite feature on all constant level lubricators.

Consult us on your requirements for lubricating equipment. Specific information will be furnished promptly to help you select suitable equipment, adapted for your individual application. Benefit from our *25 years of accumulated knowledge and skill* in this field. There is no obligation.

Write for the complete Oil-Rite catalog.

Oil Cups • Dispensers
Oiling Systems • Valves
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Oil-Rite CORPORATION
2376 Waldo Boulevard • Manitowoc, Wisconsin

Chicago. Sponsors are the American Institute of Electrical Engineers and the National Electrical Manufacturers Association. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Dec. 12-15—

Atomic Industrial Forum and American Nuclear Society. Atomic industry exhibitions and conferences to be held at the California Masonic Memorial Temple, San Francisco. Further information can be obtained from AIF, 3 E. 54th St., New York 22, N. Y.

Dec. 13-15—

Eastern Joint Computer Conference to be held at the Hotel New Yorker and Manhattan Center, New York. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers, and Association for Computing Machinery. Additional information is available from IRE, 1 E. 79th St., New York 21, N. Y.

Dec. 17—

Institute of the Aerospace Sciences. Wright Brothers Lecture to be given at the Natural History Bldg. Auditorium, Smithsonian Institution, Washington, D. C. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Short Courses and Symposia

Nov. 8-9—

Seminar on Standards and Standardization, sponsored by the American Society of Tool and Manufacturing Engineers, to be held at the Warwick Hotel, Philadelphia. Further information can be obtained from ASTME, 10700 Puritan Ave., Detroit 38, Mich.

Nov. 10-11—

Industrial Fastener Applications Institute to be held at the University of Wisconsin. Additional information is available from the Engineering Institute, 4020 Stadium, Madison, Wis.

Nov. 15-16—

Symposium on Engineering Applications of Probability and Random Function Theory, sponsored by Purdue University. Further information is available from J. L. Bogdanoff or F. Kozin, Division of Engineering Science, Purdue University, Lafayette, Ind.

Dec. 7—

Seminar on Electrohydraulic Servo Systems, sponsored by the Milwaukee School of Engineering and the Milwaukee Chapter of the Fluid Power Society, to be held at the school. Further information is available from Mel Streigel, Milwaukee School of Engineering, Technology Park, Milwaukee 1, Wis.

Jan. 9-11—

Seventh National Symposium on Reliability and Quality Control to be held at the Bellevue-Stratford Hotel, Philadelphia. Sponsors are the Institute of Radio Engineers, American Institute of Electrical Engineers, American Society for Quality Control, and Electronic Industries Association. Additional information can be obtained from James H. Goodman, Radio Corp. of America, Bldg. 1-2, Camden 2, N. J.

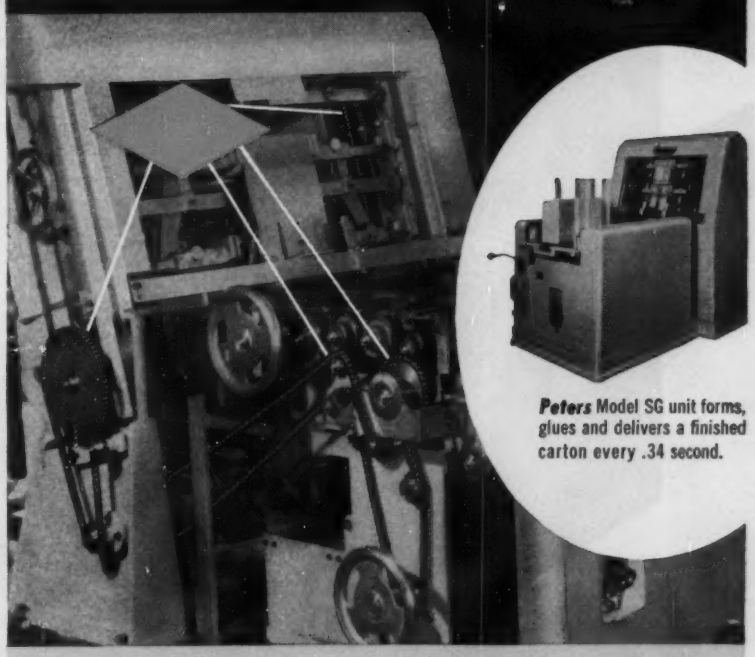
Jan. 17-18—

Bearing Symposium, dealing with design and lubrication of bearings in heavy industry, to be held at the Penn Sheraton Hotel, Pittsburgh. Sponsor is the American Society of Lubrication Engineers, 84 E. Randolph St., Chicago 1, Ill.

Jan. 23-Feb. 2—

Engineering and Management Course to be held at UCLA. Participants select four classes from a group of 22, including such subjects as reliability for modern industry, industrial psychology, engineering and research administration, and effective managerial communication. Public speaking classes are also offered. Further information can be obtained from Reno R. Cole, Co-ordinator, The Engineering and Management Course, College of Engineering, University of California, Los Angeles 24, Calif.

Peters Packaging Machine
synchronized by
DIAMOND Roller Chain
delivers 175 cartons a minute



Peters Model SG unit forms, glues and delivers a finished carton every .34 second.

A small error in split-second timing could cause a monumental snarl of cartons, glue and machine parts. To insure *precise synchronization* and dependable, trouble-free performance, Peters Machinery Company, Chicago, Illinois, specifies DIAMOND Roller Chain for high-speed packaging equipment.

The proven strength, durability and high dimensional accuracy of DIAMOND Roller Chain offer many opportunities to improve and simplify machine design . . . to solve conveying, timing and power transmission problems.

Write for catalog containing complete information on DIAMOND Roller Chain and Sprockets. Engineering assistance is available.

DIAMOND CHAIN COMPANY, INC.
A Subsidiary of American Steel Foundries
Dept. 435 • 402 Kentucky Ave., Indianapolis 7, Indiana
Offices and Distributors in all Principal Cities

DIAMOND ROLLER CHAINS

Circle 425 on Page 19

X-A-R ABRASION RESISTANT STEEL

ARMS CUTTING BLADE WITH HARD, TOUGH EDGES

Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

The business end of this land-clearing blade takes a real beating from terrain and timber. It downs brush, trees of all sizes—everything in its path. Shears off stumps at ground level. Piles cut materials into windrows. Drives its stinger through sturdy large trees to split and weaken them. Cuts a wide swath below ground level to build V-type drainage ditches. Works long, hard and fast. ◆ The point of it all? Edges made from ¾" and 1" X-A-R 15 with a hardness of 360 BHN. X-A-R is the name for tougher, harder alloy steels developed by Great Lakes Steel especially to meet abrasion problems. They're made to work better and last longer wherever materials collide with equipment—as liners, teeth, bars, blades, and plates for example. *Under conditions that commonly wear out equipment in a hurry, X-A-R*

Great Lakes Steel is a division of

X-A-R STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

Benedict-Miller, Inc. Lyndhurst, New Jersey	Joseph Demsey Co. Cleveland, Ohio	Ducommun Metals & Supply Co. Los Angeles, California	Interstate Steel Co. Evanston, Illinois	Lockhart Iron & Steel Co. Pittsburgh, Pennsylvania

Rome K/G Clearing Blades made of X-A-R—manufactured by Rome Plow Company, Cedartown, Georgia

FOR QUICK, ECONOMICAL LAND CLEARING

outwears any other type of steel. ◆ Close control during heat-treating, quenching and tempering is the secret of low carbon alloy X-A-R steels. And workability is as favorable as their hardness and toughness. Difficult problems, such as welding under cold conditions or extensive flame cutting, are handled well by X-A-R 30. For *extremely* difficult problems, choose X-A-R 15. ◆ X-A-R abrasion resistant steels, supplied in hardnesses from 360-400 BHN (or, by agreement, in lower Brinell hardnesses), are immediately available in ⅛″ to 1″ thicknesses, widths up to 72″ and lengths up to 35′. For complete technical information, write Great Lakes Steel Corporation.

X-A-R

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

NATIONAL STEEL CORPORATION

Marsh Steel & Aluminum Co.
Kansas City, Missouri

O'Neal Steel, Inc.
Birmingham, Alabama

Salt Lake Hardware Co.
Salt Lake City, Utah

A. C. Leslie & Company, Ltd.
Montreal, Canada

Circle 426 on Page 19

ALLIS-CHALMERS

New name for
an old attitude
at Allis-Chalmers

O.E.M.pathy*

A unique form of empathy...the sensitivity to understand and react to the problems of Original Equipment Manufacturers.

Why do we have this attitude? Because we *give* what we'd like to receive. At Allis-Chalmers . . . O.E.M.pathy is a deep-rooted mental habit we never aim to change. In building component products for use in your products, we draw on our own experience as an OEM in many fields. We don't have to put ourselves in your shoes . . . we're already wearing a similar pair. This OEM frame of mind affects our basic approach in everything we do for you . . . not in a superficial way . . . but from the basis of sound, well-chosen beliefs gained as OEM's ourselves. It shows in the products we offer as components, in our service, our delivery, our ability to supply "specials" and to fit our performance to your needs. O.E.M.pathy directs our thinking, our attitudes, our actions. *Industrial Equipment Division,* ***Allis-Chalmers,*** *Milwaukee 1, Wisconsin.*

A-1279

PRODUCTS FOR YOUR PRODUCTS
FROM ALLIS-CHALMERS

MOTORS CONTROLS PUMPS VALVES COMPRESSORS

ELECTRONICS.... HYDRAULICS.... HEAT TRANSFER.... LUBRICATION

NUCLEONICS.... SONICS.... COOLANTS.... DIELECTRICS:

Monsanto Specialized Fluids and new FluiDesign Service can help you benefit from

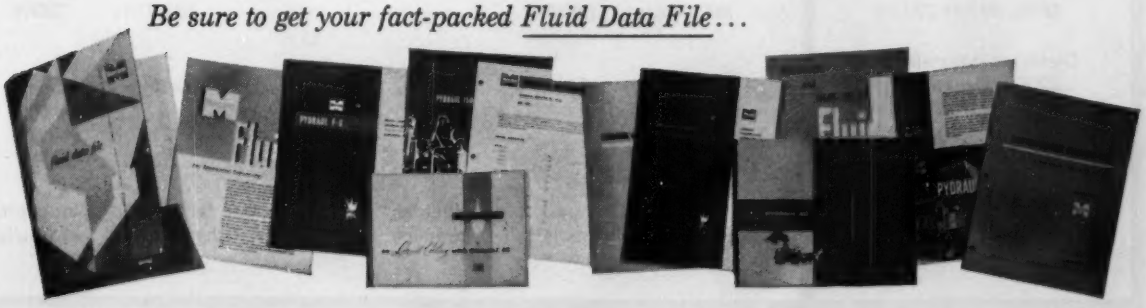
A RENAISSANCE IN ENGINEERING DESIGNS

Conventional fluids (water, oil) impose well-known restrictions on engineering designs. Heat, radiation, fire hazard, shear, electrical requirements, extreme pressure, friction—all cause problems—limit you in design flexibility, in imaginative thinking, in new ideas.

Monsanto's specialized synthetic fluids—chemically tailored to minimize many design restrictions in power transmission, lubrication, heat transfer, insulation, cooling—make new and improved designs practical. Spawned by advances in specialized fluid properties and broadening of fluid functions—a renaissance in engineering concepts is starting now. These specialized fluids open new design opportunities for your exploration.

Monsanto's new FluiDesign Service—established to help you meet your needs best from the capabilities of some thirty specialized fluids—can give you valuable guidance at the outset of your design exploration and engineering planning. For example, the next two pages provide you with the FluiDesign Service Report, "Fire-Resistant Fluids for New *Mechanical* Applications." Among the fifteen fluids described, one or more may allow you to engineer your next design for safer, more efficient performance.

Be sure to get your fact-packed Fluid Data File...



From Monsanto FluiDesign Service . . .

FIRE-RESISTANT FLUIDS FOR NEW

The fifteen fire-resistant fluids described here are now at work in industrial and aircraft hydraulics, heat transfer and other mechanical applications which require a firesafe fluid. When you need a fire-resistant fluid for any application, one of these Monsanto specialized fluids may be adaptable to your job.

Consider how these and other specialized fluids might solve special-design engineering problems for you. If one of these fifteen does not meet your present requirements, Monsanto FluiDesign Service will make other recommendations for your application. Just send a brief description of the conditions which your fluid must meet.

For the specific properties you need, only Monsanto can make and help you select from so many kinds of specialized fluids, including

	Skydrol 7000	Skydrol 500A	Pydraul 60	Pydraul 150	Pydraul F-9	Pydraul A-200
Flash point, °F., Cleveland Open Cup	425°	360°	435°	380°	430°	380°
Fire point, °F., Cleveland Open Cup	475°	425°	460°	470°	675°	680°
Autoignition temp., °F.	1050°	>1100°	>1000°	>1100°	>1100°	>1200°
Viscosity, cs. 100°F.	15.5	11.5	11.1	30.8	47	49.5
210°F.	4.00	3.92	2.65	8.0	5.5	4.8
Pour point, °F.	< −70°	< −85°	−70°	−55°	−5°	10°
Boiling point, °F. 760 mm. Hg	709°	—	707°	617°	644°	620°
Max. bulk temp., °F. long term	200°	225°	200°	200°	300°	300°
Coefficient of thermal expansion, per °F.	0.00042	0.00045	—	0.00042	0.00041	0.00040
Specific heat, 25°C.	0.42	0.38	0.42	0.40	0.32	0.28
Thermal conductivity Btu/hr./ft.^{2}/ft./°F.	0.0723	0.0777	0.047	0.070	0.067	0.059
Bulk modulus, psi	328,000	308,000	328,000	319,000	387,000	400,000
Specific gravity, 25°/25°C.	1.08	1.07	1.09	1.13	1.28	1.42
Resistivity, ohm-cm, 25°C.	5×10^8	4×10^7	—	—	1.5×10^9	3.3×10^{10}
Dielectric strength, 25°C., 60 cps., 0.1 in.	36KV	12KV	—	—	33KV	38KV
Dielectric constant, 25°C., 1000 cps.	8.87	8.81	—	—	6.25	—
Power factor, % 1000 cps., 25°C.	0.49	—	—	—	2.2	—
Original use	aircraft hydraulics	aircraft hydraulics	industrial hydraulics	industrial hydraulics	industrial hydraulics	industrial hydraulics

MECHANICAL APPLICATIONS

phosphate esters, silicate esters, diphenyl and terphenyl and chlorinated derivatives. Monsanto has the best facilities and broadest know-how for making the widest variety of fluid "base" stocks and additive modifiers of any chemical manufacturer. Whatever your requirements, consult Monsanto if you need a fluid for a new product or machine-design concept.

Write:
MONSANTO CHEMICAL CO.
Organic Chemicals Division
FluiDesign Service, Dept. 2764A
St. Louis 66, Missouri

SKYDROL, PYDRAUL, AROCLOR: Monsanto T. M.s, Reg. U. S. Pat. Off.

Pydraul 625	Pydraul AC	OS-81	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Transformer Askarel
465°	420°	—	295°	308°	360°	379°	—	460°
745°	650°	—	349°	460°	>610°	>640°	>660°	460°
>1100°	1100°	1100°	>1000°	>1100°	>1200°	>1200°	>1200°	1000°
135	88.2	35.25	4.6	6.9	17.2	45.3	500	5.0
6.1	5.15	3.18	1.2	<1.8	2.5	3.2	6.14	1.5
20°	20°	15°	34°	−32°	2°	20°	50°	47°
724°	688°	—	527°	554°	617°	644°	689°	460°
300°	300°	300°	600°	600°	600°	600°	600°	600°
—	0.00040	—	0.00039	0.00040	0.00038	0.00039	0.00037	0.00039
—	—	0.31	0.33	0.31	0.29	0.27	0.26	0.25
0.065	—	—	0.067	0.063	0.058	0.057	0.054	0.050
375,000	375,000	—	—	—	—	428,000	—	—
1.36	1.35	1.40	1.18	1.26	1.38	1.45	1.54	1.57
—	—	—	1×10^{12}	1×10^{12}	1×10^{12}	1×10^{12}	1×10^{12}	5×10^{11}
—	—	—	>35KV	>35KV	>35KV	>35KV	>35KV	35KV
—	—	—	4.5	5.4	5.8	5.6	5.0	4.0
—	—	—	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
industrial hydraulics	air-compressor lubrication	turbine and compressor lubricant	plasticizer	plasticizer	capacitor impregnant; heat transfer	heat transfer	capacitor impregnant	transformer dielectric

Circle 428 on Page 19

precision engineered control switches

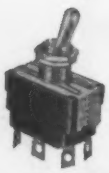
designed with brand new features

Keeping pace with design engineers, Circle F offers modern control switches for every possible application. New economies are now possible through the use of standard switches readily modified to meet any particular specification. Circle F's advanced standards of quality-controlled manufacture makes possible assembly-line production of highest quality "custom-made" switches in less time and at lowest costs. Whatever your need, write Department S for fullest information and helpful engineering assistance.

M-1886-L4P
NEW "PADDLE" HANDLE SWITCH

1885-6
NEW THREADED PLUNGER SWITCH
for any cap

L-40



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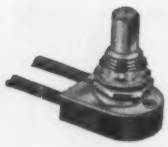


1885

1903

CIRCLE F's "Fine" Silver Contacts reduce arcing on slow-make, slow-break AC and insure long, dependable switch life.

CIRCLE F MFG. CO.

TRENTON 4, NEW JERSEY • For your wire requirements: Eastern Insulated Wire Corp., Box 591, Trenton, N. J.

Circle 431 on Page 19

HAYNES ALLOYS

RESEARCH REPORTS

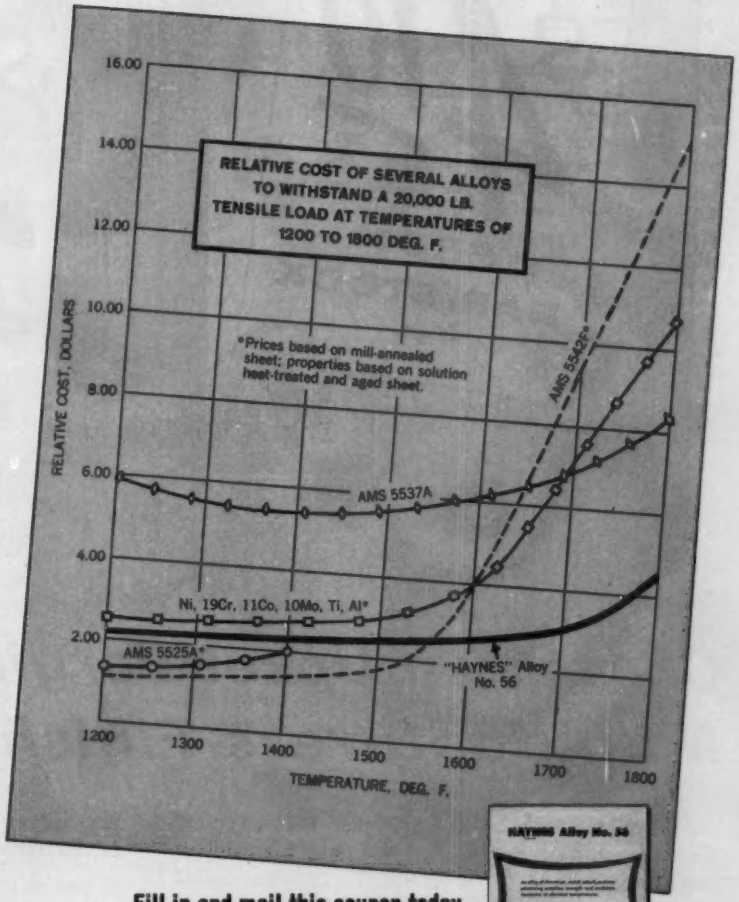
New High-Temperature Alloy Improves Cost-To-Strength Ratio

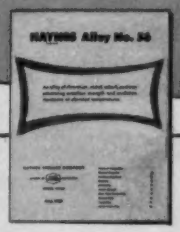
Excellent strength and oxidation resistance in the 1200 to 2000 deg. F. range are among the features of HAYNES Alloy No. 56—a new high-temperature alloy developed by Haynes Stellite Company.

A sampling of its cost advantages at a given tensile load, compared with other high-temperature alloys in the graph at the right, is well worth your study.

Alloy No. 56 can be readily hot-worked and formed. It is easy to heat treat. It comes in the form of sheet, plate, bar, wire, and coated welding electrodes, and can be furnished as sand-, investment-, and resin shell-mold castings. The coupon below will bring you a wealth of technical data.

The new iron-base alloy contains nickel, cobalt, chromium, and molybdenum. It has high strength at temperatures up to 1500 deg. F and maintains useful strength at temperatures as high as 2000 deg. F.





Fill in and mail this coupon today

Haynes Stellite Company, Dept. 61
270 Park Avenue, New York 17, N.Y.

Please mail me the free, 16-page properties-data booklet on the new HAYNES Alloy No. 56.

NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

Haynes" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

Circle 432 on Page 19

Champion Upset Forgings Cut Valve Manufacturer's Finished Cost 30%!

At first glance this valve part looks like a typical screw machine product. But see that big wad of metal on the end of the stem? . . . It's the tip-off that you can save money with an upset forging.

Any automatic screw machine part must start with stock of the largest part diameter and be worked down . . . with considerable waste.

In upset forging, you generally start with the smallest diameter and increase the part size to the largest diameter . . . with almost no waste. Forging also increases strength, by directioning grain flow in the metal.

If you're using similar parts, check with Champion and see how much you too can save by starting with an upset forging.

THE CHAMPION RIVET COMPANY
T. P. Champion, President
CLEVELAND 5, OHIO • EAST CHICAGO, INDIANA

When it's a vital part, better make it **FORGED**

Circle 433 on Page 19
Circle 434 on Page 19→

Longer Life! Superior Dependability!

THE ALLEN-BRADLEY LINE of BULLETIN 700 RELAYS IS COMPLETE!

TYPE B general purpose relay shown with 2 N.O. and 2 N.C. contacts. Made with up to 8 poles in various arrangements.

TYPE BX universal relay shown with 4 poles having both N.O. and N.C. contacts. Additional contacts on the 6 and 8 pole relays are N.O. only.

THESE IMPROVEMENTS ARE *IMPORTANT!*

These improved Bulletin 700 Type B and Type BX relays are establishing new standards for relay life and reliability. New design increases mechanical life by *at least 5 times* . . . a new contact motion insures *at least 10 times* greater electrical reliability. Double break, silver contacts never need maintenance, and the new molded coil is impervious to the most severe atmospheric conditions.

These new A-B relays—with their *extra millions of trouble free operations at no increase in price*—are a bargain in the relay field. Write for complete details, today.

NEW ENCLOSURES

for the Bulletin 700 relays are styled by Brooks Stevens—internationally famous industrial designer. Note the "family" resemblance of these enclosures.

NEMA 1

NEMA Type 1 for general purpose applications with wrap-around cover for ready accessibility. It has a "quality" appearance.

NEMA 4

NEMA Type 4 enclosure for applications that require a watertight and weatherproof seal.

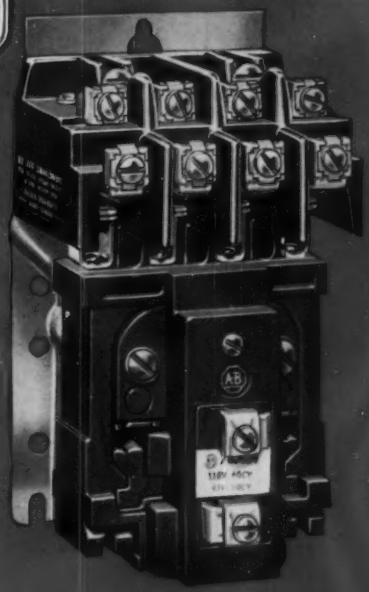
NEMA Type 7 enclosure for NEC Class 1, Group D hazardous gas locations.

NEMA 7

11-60-M

A-B QUALITY

TYPE BR Bulletin 700 convertible contact relay shown with four poles. Made with up to six poles in line.



No other relay offers such simplicity in changing contacts from N.O. to N.C. (or vice versa)—it takes only 60 seconds!

A four pole unit provides any of the contact combinations otherwise available only with five relays of the fixed contact type. You can reduce your relay inventories. In tests, this relay has *proved* it will provide many millions of trouble free operations. Double break, silver contacts never need servicing. Also, each relay can have one or two complete and full rated contacts added to its base—in the field—without increasing space requirements. If you don't know about the Type BR relay, let's get acquainted.

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley, Canada Ltd., Galt, Ontario

QUALITY MOTOR CONTROL

ACTUAL TESTS* PROVE

Allen-Bradley Standard Duty Push Buttons can be installed

in about half the time!

In accurately timed tests, Allen-Bradley standard duty push buttons required *about half the installation time*—on the average—than each of four other popular makes. This saving in installation time means "dollars" saved on the job. How come only the famous A-B standard duty push button possesses this time and moneysaving advantage? The answer lies in the molded, wrap-around cover—which also contains the contacts. When the cover is removed, the wiring terminals are *out in the open*—ready for wiring—and you have plenty of working space. The two cover screws are captive—they cannot fall out and get lost. And with the contacts in the cover, they are protected against accidental damage and careless wiring. Naturally, these push buttons have double break, silver contacts that never need service attention. There are two concentric knockouts on each end of the base, which are removed from the *outside*—the heavy, pressed steel base will not bend out of shape.

Your local A-B distributor has these Bulletin 800 push buttons *in stock*. Call him today—you'll save time and money on your next job.

**Using recognized standard duty push buttons, installations were made by an experienced electrician under identical conditions. He was not connected with Allen-Bradley Company in any manner.*

A-B STANDARD DUTY PUSH BUTTONS
Made as a one-, two-, or three-unit station—with pilot light available. Readily changed for horizontal or vertical mounting. Convertible two- or three-way selector switch supplied with or without pilot light.

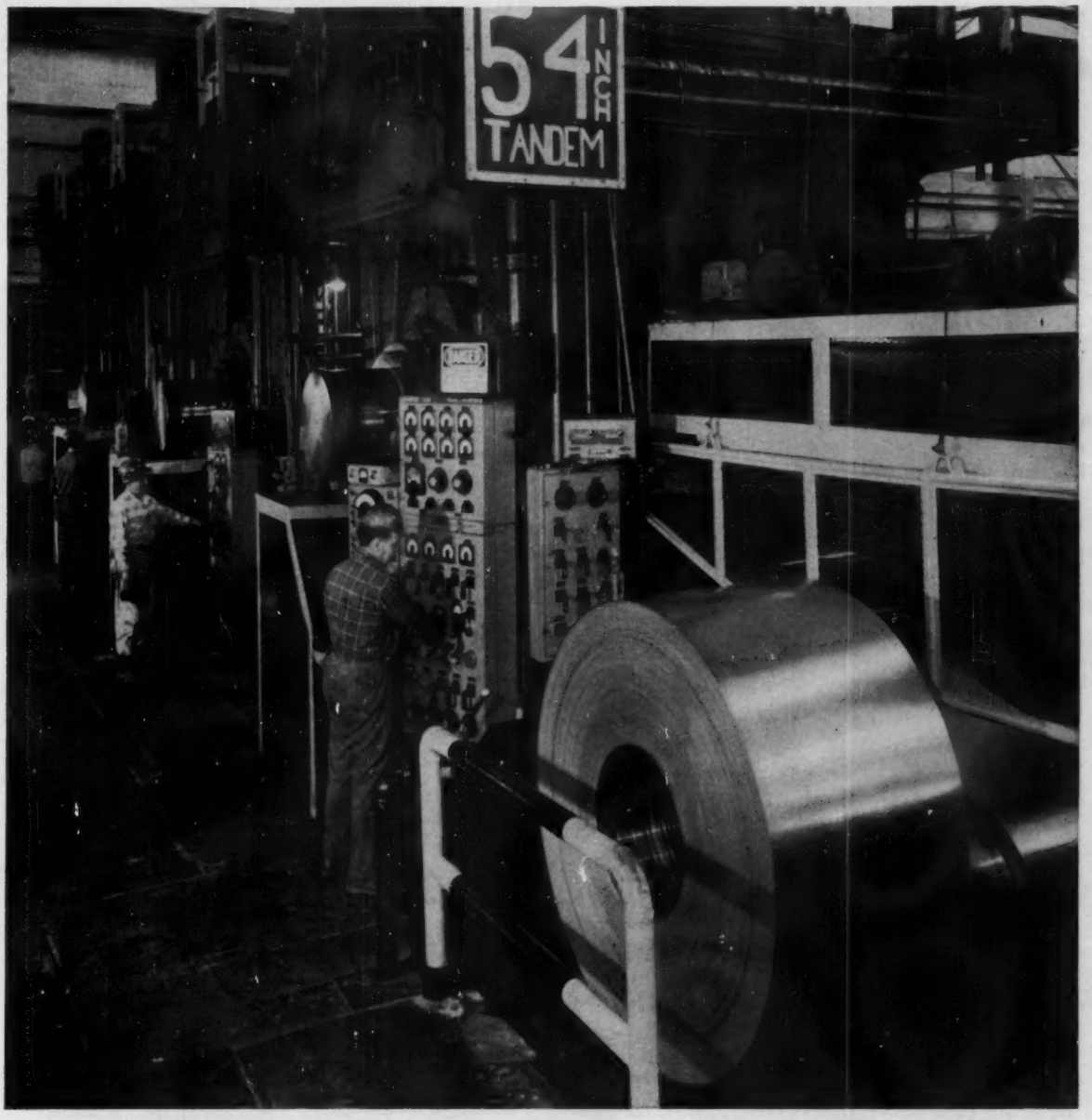
17-60-R

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ontario

QUALITY MOTOR CONTROL



We baby these sheets to do a man's job

Here goes a coil of Bethlehem sheets, sinewed to stand up under rugged duty, as only steel can. To bring sheets to this superlative condition, Bethlehem pampers them like a newborn babe.

From open hearth to shipping room, their progress is checked under the watchful eyes of man and X-ray. Slabs are expertly scarfed. Reheating is controlled by the latest scientific instruments. Rolling and coiling temperatures are carefully controlled.

The finished sheet—whether hot-rolled or sent through the 10 additional steps of cold-rolling—is the result of meticulous care all along the way. You can *always* count on Bethlehem sheets to do a man's job! Put them to the test in your plant.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 435 on Page 19

NEW Cramer miniatures for military use record elapsed time, - drive positioning devices

TYPE 620 Elapsed Time Indicator (top) shown approximately full scale, is offered for operation on 115 volt, 60 or 400 cycle power. Dimensionally, the version illustrated meets MS-28053 and NEMA standards, and is front-panel mounted through a 1-19/32″ diameter opening. All relevant test requirements of MIL-M-7793B and MIL-E-5272B are met or exceeded (to 50 G's shock, 2000 cycle vibration). An optional back-panel mounting adapts to existing panel drilling. Hermetically sealed, Type 620 has recessed solder lugs at rear for electrical connections. Total registration 9,999.99 hours, weight about 4 ounces. Designed primarily for military use, the unit will give unsurpassed service in rugged industrial applications.

TYPE 120 Miniature AC Motor (right) is rated 115 volts, 60 cycles. Permanent-magnet design assures fast response and truly synchronous operation. Running torque .08 inch ounce at 240 rpm rotor speed, weight approximately 2 ounces.

TYPE 821 Ungoverned DC Motor (bottom) for no-load speeds from 8,000 to 20,000 rpm. Typical 28-volt armature develops 14,200 rpm no-load, 12,600 rpm at 0.1 inch ounce load, with current drain about 100 ma. Weight under 2 ounces. Meets MIL-T-5422E.

TYPE 890 115-Volt 400-Cycle Motor (left) is a single-phase hysteresis-synchronous motor. Available as basic ⅞″ motor (like Type 120 at right), or in 1-inch flange-mounted can illustrated, containing motor and capacitor network. Produces .01 inch ounce torque at 3000 rpm. Weight under 2 ounces.

Write for complete information, specifications.

ELECTROMECHANICAL DIVISION

CRAMER CONTROLS CORPORATION

CENTERBROOK, CONNECTICUT

Circle 436 on Page 19

ISSUE NO. 20

the neg'ator® sketchbook

The NEG'ATOR® Spring is a new basic mechanical component—a coiled band spring which extends many times its original size without the increasing force common to conventional springs. Used as an extension spring, a motor, band, clamp, or clip, this revolutionary new constant-force component upsets all previous spring principles by doing what springs have never done before.

BRUSH HOLDER SPRINGS COMPARED

A Step-by-Step Evaluation of the NEG'ATOR® Spring & Conventional-Type Springs

In rotating electrical machinery, brush pressure is probably the major influence on the rate of brush wear. Unnecessarily high brush pressure causes excessive friction and increases *mechanical* wear. Insufficient pressure gives poor contact, causes sparking and heating, and increases *electrical* wear.

Using conventional springs, a designer is obliged to specify a design pressure higher than needed. This is done because the designer knows that the pressure will decrease as the brush wears away, relaxing the spring. Unless regular adjustments are made, the pressure continues to fall below optimum until arcing occurs.

Ideally, brush pressure should be maintained at a constant, optimum value throughout the life of the brush. Motor makers are now realizing this ideal—with the NEG'ATOR constant-pressure brush spring. The chart on the reverse of this page provides a step-by-step evaluation of NEG'ATOR and conventional springs.

NOTE: Design help on NEG'ATOR brush springs can be obtained by requesting Bulletin 310P.

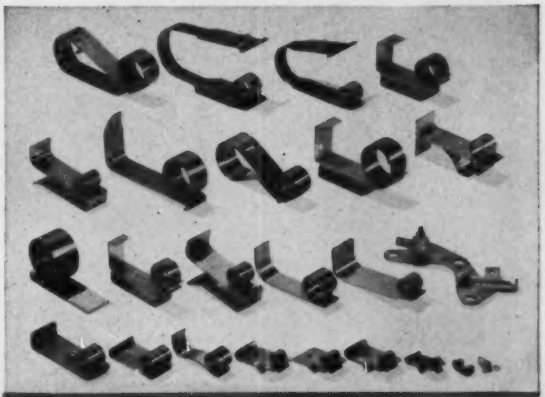


FIG. 1. NEG'ATOR constant-pressure brush springs have provided designers of large and small electrical equipment with the means of obtaining optimum pressure throughout brush life. This photo shows a random assortment of brush holders made for major motor and generator makers. All of these utilize the NEG'ATOR spring to gain the advantages of design simplicity and constant pressure.

NEG'ATOR MOTORS NOW DRIVE MOST MODERN MOVIE CAMERAS

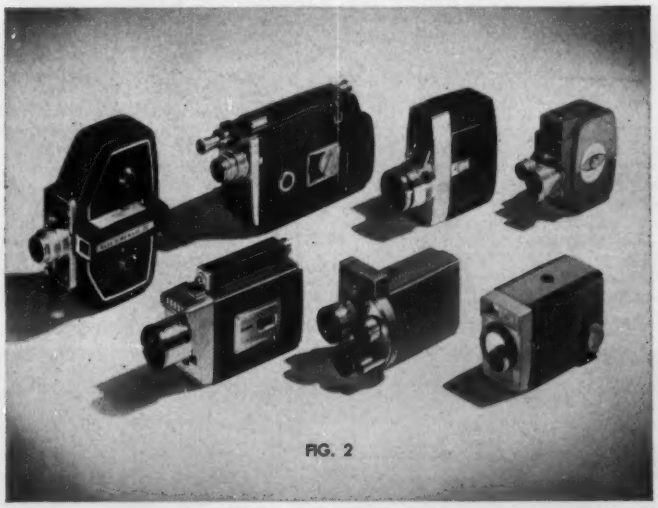
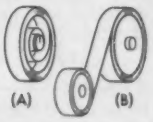


FIG. 2



Four years ago, Hunter published an article which began with the sentence, "The first NEG'ATOR Motor powered movie camera is now on the market."

Now, practically every major American manufacturer uses a NEG'ATOR or SPIR'ATOR motor as a drive unit in movie cameras.

The reason: SPIR'ATOR(A) and NEG'ATOR(B) drive units provide longer film run per wind, greater mechanical efficiency, excellent speed regulation, operating ease, and sharply reduced production costs through simplified design.

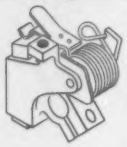
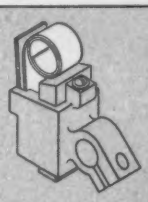
All of the new cameras shown in Fig. 2 use Hunter spring power—either a NEG'ATOR motor or a SPIR'ATOR motor (a NEG'ATOR derivative). All offer advantages never before available with other types of spring motors. Designers concerned with mechanical drives would do well to check into the characteristics of the NEG'ATOR motor. Start by requesting a copy of Bulletin 310 Mb.

PUBLISHED BY HUNTER SPRING COMPANY • LANSDALE, PENNSYLVANIA

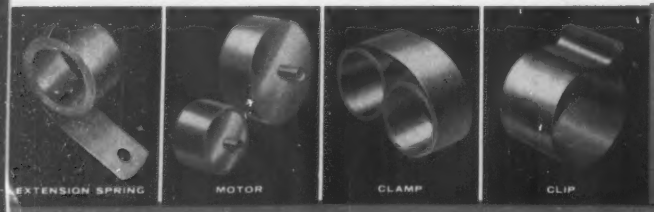
A Division of American Machine and Metals, Inc.

For an additional copy of this sketchbook Circle 437 on Page 19

BRUSH HOLDER SPRINGS COMPARED

Factor	 Brushholder With Conventional Spring		 Brushholder with NEG'ATOR Spring (No Adjustment Required)
	Non-Adjustable	Adjustable	
Fields of Application	Small motors, household appliances, toys, tools. Short-life or intermittent service machines.	Larger machines, under supervised maintenance schedule.	All types of rotating electrical machinery employing commutator or slip ring.
Rate of Brush Wear	Increasing. As brush wears, spring extends, and contact pressure diminishes, permitting poor contact and inviting arcing in extreme cases.	Varying. If adjusted *above* optimum pressure, friction wear is rapid, diminishing until spring extends to optimum pressure, wear increases thereafter, due to diminishing pressure and poor electrical contact. Shorter intervals between adjustment reduce over-all rate of wear.	Holds only one pressure—the optimum—throughout life of brush, regardless of any change in length of brush. Constant minimum rate of wear.
Brush Life	Limited by rapid electrical and mechanical wear, brush length limited by range of useful spring pressure.		Constant minimum rate of brush consumption through wear increases brush life. Additional life obtainable through using longer brush without increasing range of spring pressure. Larger portion of brush material available for useful service.
Heating	High contact pressure (with new brush) causes friction wear. Low contact pressure (worn brush) permits heating through arcing.	Same as other conventional spring unit, except that more frequent adjustment can help to reduce heating.	Held to minimum through automatic maintenance of constant optimum contact pressure.
Space Requirement	Small—through elimination of adjustment devices.	Considerable, to permit adjustment devices and accessibility thereto.	Minimum. Simple brushholder without adjustment fixtures, leaves ample room for inspection or arrangement of additional units around commutator or slip ring.
Design, Parts	Simple design, minimum number of parts. Entire brush or brush and holder replaced when worn.	A complete assembly of spring, holder, fasteners and adjusting members to be designed, fabricated, assembled and stocked for replacement.	NEG'ATOR springs and back-up plate readily held in simple stamped, cast or extruded one-piece box, reducing cost of manufacture and maintenance.
"Riding" Characteristics	Slight rotor flat or eccentricity gives rise to poor commutation due to brush bouncing off rotor. Extra mass of brush holders involving linkages accentuate this action.		Low mass and absence of any harmonic frequency permit greatly improved following action and shorter reaction time when rotor is slightly out of round.
Duration of Optimum Commutation	Small span of brush life.	Brief, but recurring as frequently as pressure is readjusted.	Unvarying optimum pressure held without intermediate adjustment.
Replacing Brushes	Usually time-consuming and difficult, depending upon the holder design. In some cases, skilled labor is required.		Easily accomplished. Can be done by unskilled labor. Only one hand required in most cases.

HS567—3M—960DB



HUNTER SPRING COMPANY
A Division of American Machine and Metals, Inc.
29 Spring Avenue, Lansdale, Pennsylvania
SPRINGS • STAMPINGS • QUALITY CONTROL EQUIPMENT

HUNTER Pioneers in Springs

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For an additional copy of this sketchbook Circle 437 on Page 19

"ALCOA ALUMINUM SCREW MACHINE STOCK ALLOY 6061...FOR VERSATILITY!"

Precision-made, high-volume screw machine parts cost less in aluminum

Here's versatility! Alcoa Alloy 6061-T6 or -T651, being lightweight aluminum, gives you three times more parts per pound than other, heavier metals. And this alloy gives *superior* finishes . . . can be joined easily by welding, brazing or soldering . . . may be anodized in a wide variety of colors . . . stands up to service under corrosive conditions! Machining speed, light weight and end-use adaptability . . . all add up to faster production, lower machining costs, higher profits.

Want to make cost conversions from brass to aluminum and compute costs quickly? Ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator.* Get your free *Alcoa Screw Machine Stock Estimating and Operating Data Book,* too . . . packed with technical data on aluminum screw machine stock. And ask about other Alcoa alloys: 2011-T3 or -T8 for superb machinability and still faster cutting, 2017-T4 or -T451 and 2024-T4 or -T351 for strength at low cost. Aluminum Company of America, 840-X, Alcoa Building, Pittsburgh 19, Pa.

AS AN ALCOA CUSTOMER, YOU GET ALL THESE "EXTRA BONUSES":

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa® Aluminum turnings and borings.
3. Extensive mill and distributor inventories to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

ALCOA ALUMINUM

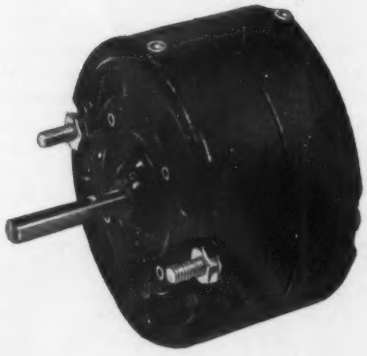
SCREW MACHINE STOCK

Circle 438 on Page 19

BEARING DESIGN OF
EMERSON ELECTRIC MOTORS

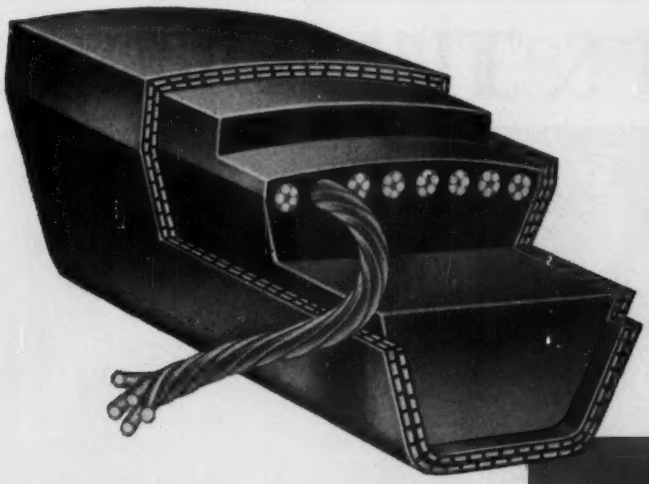
Is Self-Oiling, Self-Aligning to assure Free Starting and Smooth Operation at all times

The bronze bearing in Emerson Electric Motors has thousands of tiny cells that cause the bearing to act as a metal sponge and feed the shaft journal a controlled flow of lubricant. In cooling, it draws off excess oil to give free starting at low temperatures. Self-Alignment minimizes friction and greatly increases motor life when you install *Emerson Electric Motors* in your appliances and equipment. Emerson Electric Motors are custom-engineered to meet your specific needs. Call us *today* . . . you'll like our way of doing business!



EMERSON ELECTRIC *of St. Louis • Since 1890*

DEPT. M34, 8100 FLORISSANT • ST. LOUIS 36, MO. • CO 1-1800

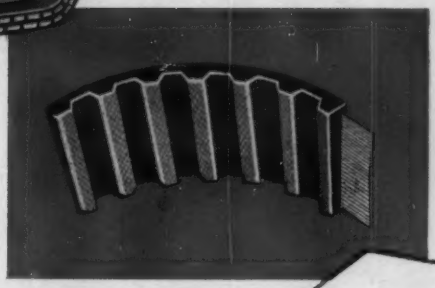


Need High Capacity In Compact Space?

DA 358 V-BELTS. This major design improvement in V-Belts brings you unprecedented compactness, high capacity and drive economy.

Chain and Gear Benefits with No Metal-to-Metal Contact?

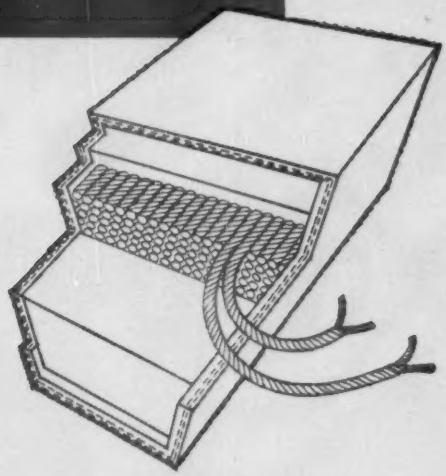
DA POSITIVE DRIVE BELTS. Revolutionary tooth-grip principle; no stretch; no constant lubrication. Highly versatile.



Whatever your V-Belt needs, DURKEE-ATWOOD *meets them*

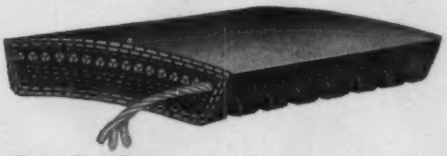
What do you want in a V-Belt? You want consistent performance, long trouble-free life and full-rated power transmission. That means the belts must be made of the finest quality materials, with careful attention to engineering details, manufacturing processes and testing procedures. Durkee-Atwood V-Belts are made of the newest high tenacity synthetic fibres to assure length stability in storage. The exclusive Durkee-Atwood "Iso-Dynamic" Vertical Matching Machine eliminates the "sag error" that develops when V-Belts are matched on horizontal equipment. This assures equal power transmission from all belts on multiple drives . . . Look to Durkee-Atwood for *quality, service* and *savings* ...*the most complete line of industrial V-Belts.*

Look for the DA DURKEE ATWOOD *On Your V-Belts*



40% Extra Capacity in Regular V-Belts?

RED SHIELD MULTIPLE V-BELTS. Increased capacity at no increased cost. Available in oil and heat resistant and static dissipating constructions.



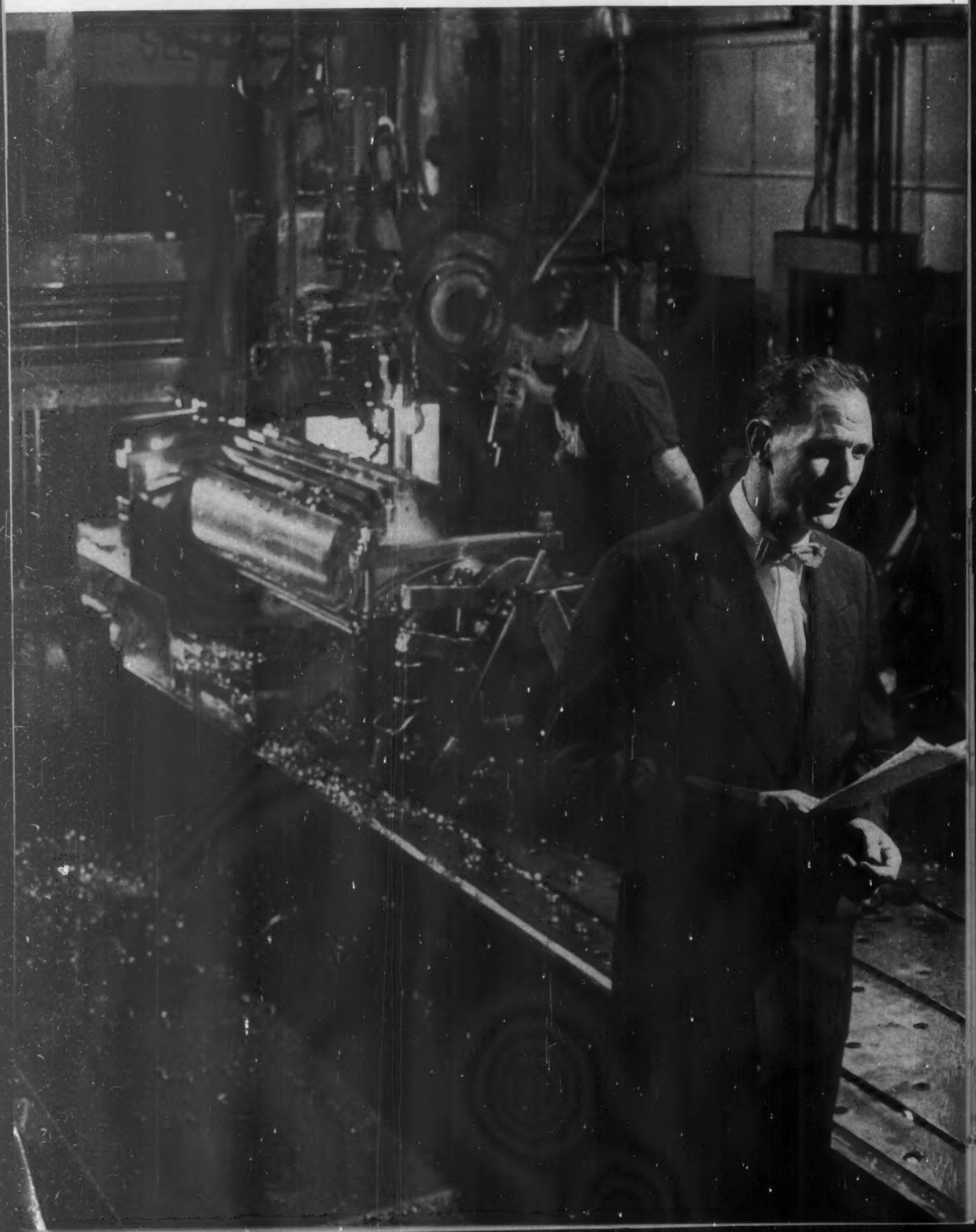
Top Performance in Variable Speed Drives?

VARIABLE SPEED BELTS. For constant performance. Abrasion-resistant cover; crowned cross section maintains stability under extreme loads.

DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY MINNEAPOLIS 13, MINNESOTA

THE MAN & THE DRIVES



FROM WESTINGHOUSE

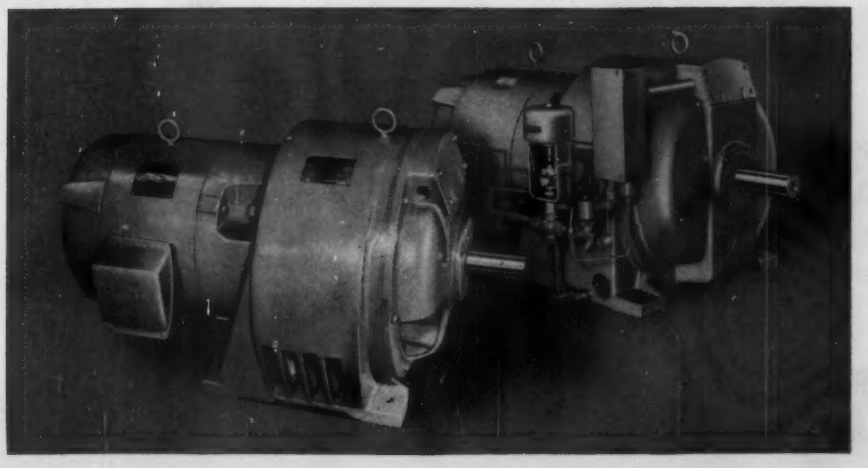
Mr. Westinghouse and MagnaFlow Drives Bring Simple Solution to Speed Control Problems, Save Money and Space, Too!

Westinghouse MagnaFlow* electromagnetic drives—air or liquid cooled—provide infinitely adjustable speeds from standstill to top speed with regulation guaranteed at $\pm 2\%$ of top speed over a 17-to-1 speed range (even closer regulation when desired). Control is smooth and stepless.

These compact drives, having a minimum number of parts, are built for rough, trouble-free service. The unique electromagnetic coupling maintains adjustable output speed without the use of pulleys, belts, brushes, commutators, slip rings or rotating windings. A rugged Life-Line® "A" motor supplies reliable a-c drive power. No power converting equipment needed—only a small, static exciter and an operator's control station. Initial cost is low; installation—easy and inexpensive.

Your Man from Westinghouse is ready now to help you apply MagnaFlow drives . . . and any other drives you may need. Call him . . . or write for a copy of Westinghouse MagnaFlow Electromagnetic Drives (B-7875), Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. You can be sure . . . if it's Westinghouse. J-22162

*Trade-Mark



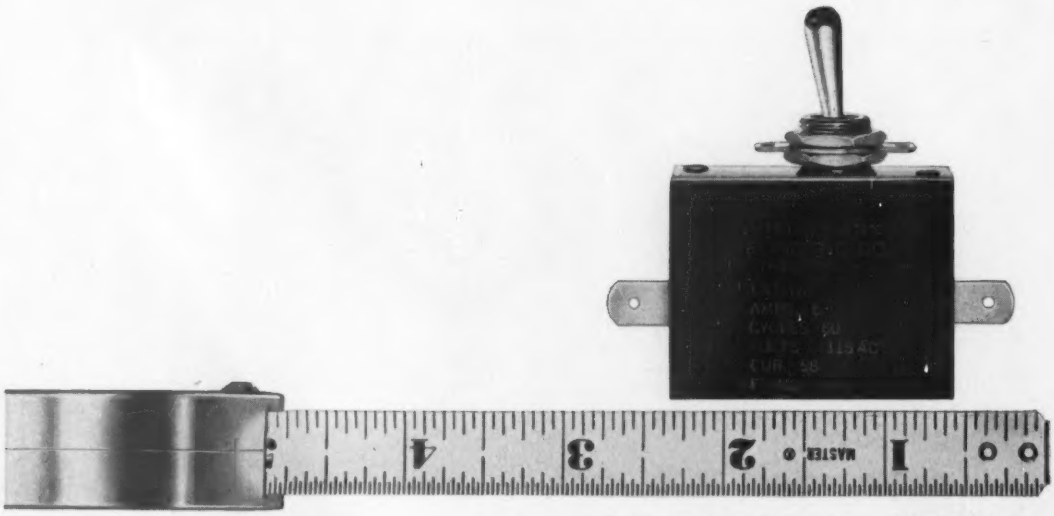
MagnaFlow drives—air cooled (foreground) and liquid cooled—are available in various horsepower ratings for winders, conveyors, fans, pumps, extruders and other machinery in all industries.

Westinghouse

Circle 441 on Page 19

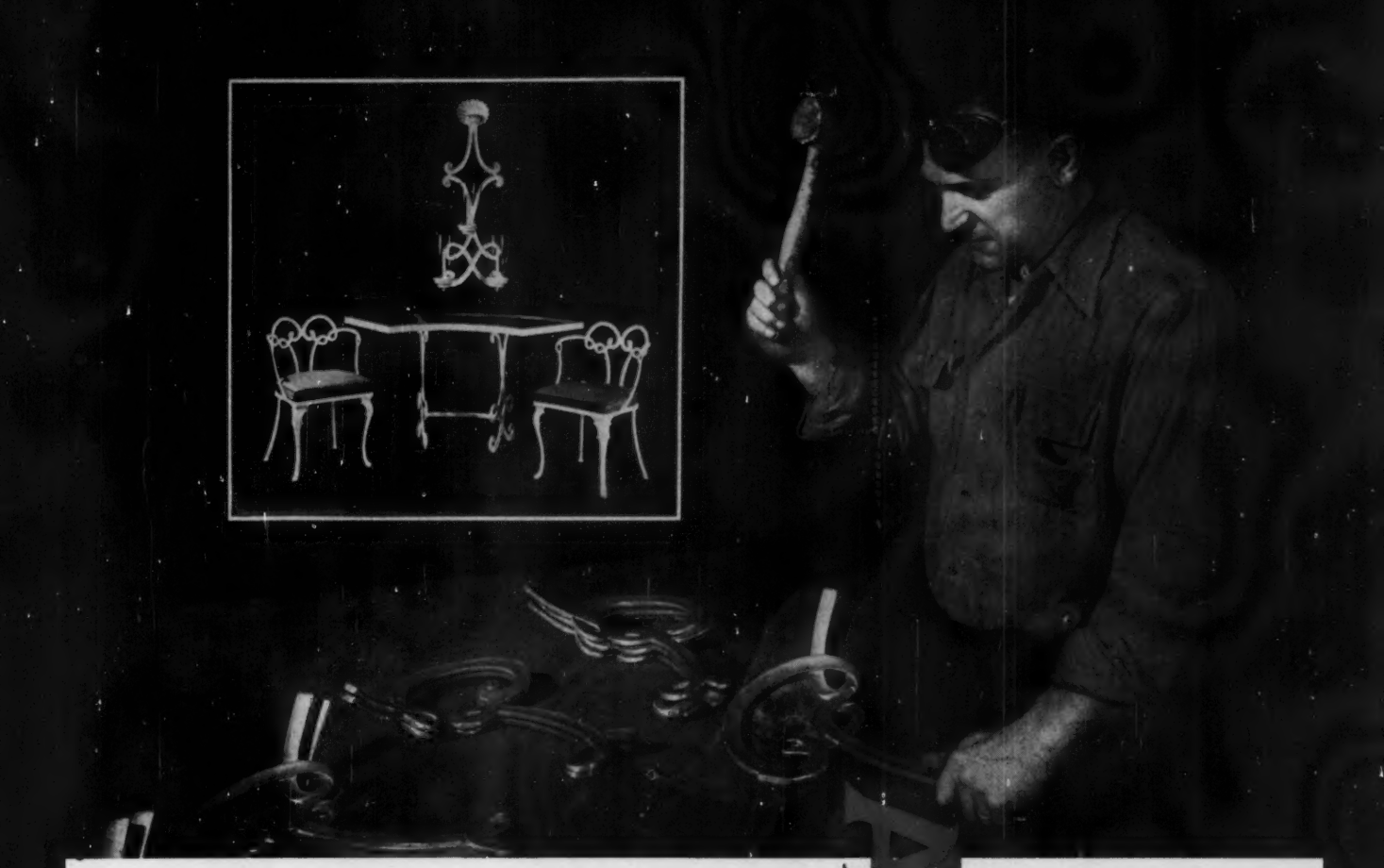
Heinemann's new Series VP circuit breaker can give you elbow room to work with in engineering compact equipment. Just 2½" x ⅝" x 2¼" overall, it tips the scales at a piddling 1½ ounces, and requires only a half-inch of panel space (without the ON-OFF plate). Yet, small as it is, it can double in brass. The standard series-trip model, for example, can serve you as a toggle switch as well as overload protector. Other models with special internal circuit constructions (shunt-trip, relay-trip, calibrating-tap, auxiliary contacts) can do even more to simplify a schematic, eliminate components. □ Like all Heinemann circuit breakers, the VP breaker is magnetically actuated, has a hydraulically controlled, inverse time delay. Completely non-thermal, it doesn't have to be de-rated for high ambient temperatures. □ You can have this breaker in any integral or fractional current rating from 0.050 to 15 amps, for 110 V, 60 or 400 cycles AC, or 50 V DC. Our new Bulletin VP will give you more information. Drop us a line, and a copy's yours.

HEINEMANN ELECTRIC COMPANY ◆ 172 BRUNSWICK PIKE, TRENTON 2, N.J.



Try this breaker for size

SA 2316



Highly workable and tough!

ADAPTALOY ALUMINUM CASTING ALLOY

for complex cold forming

Adaptaloy, an exclusive Federated alloy, has the highest elongation and impact strength of any sand cast alloy not requiring special practices or heat treatment. It's an excellent lightweight material for moderate strength castings that must be cold formed or bent during processing or installation. Dimensionally stable, castable by conventional foundry methods, easily anodized and color dyed. Adaptaloy is being used successfully for ornamental grilles, ball joints, brackets, valve handles, furniture, clamps, machine parts. Write or call for descriptive booklet to Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N.Y. Telephone REctor 2-9500, or call your nearest Federated sales office.

Adaptaloy castings are easily cold formed and simplify assembly for the Sandfort Furniture Co., N. Y. Inset photo illustrates one of Sandfort's cast aluminum furniture settings—all are cast of Adaptaloy.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

FEDERATED METALS DIVISION

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ALTON, ILLINOIS
Alton: Howard 5-2511
St. Louis: Jackson 4-4040

BALTIMORE, MARYLAND
Orleans 5-2400

BIRMINGHAM, ALA.
Fairfax 2-1802

BOSTON 16, MASS.
Liberty 2-0797

CHICAGO, ILL. (WHITING)
Chicago: Essex 5-5000
Whiting: Whiting 826

CINCINNATI, OHIO
Cherry 1-1678

CLEVELAND, OHIO
Prospect 1-2175

DALLAS, TEXAS
Adams 5-5034

DETROIT 2, MICHIGAN
Trinity 1-5040

EL PASO, TEXAS
(Asarco Mercantile Co.)
3-1852

HOUSTON 29, TEXAS
Orchard 4-7611

LOS ANGELES 23, CALIF.
Angelus 8-4291

MILWAUKEE 10, WIS.
Hilltop 5-7430

MINNEAPOLIS, MINN.
Tuxedo 1-4109

NEWARK, NEW JERSEY
Newark: Mitchell 3-0500
New York: Digby 4-9460

PHILADELPHIA 3, PENNA.
Locust 7-5129

PITTSBURGH 24, PENNA.
Museum 2-2410

PORTLAND 9, OREGON
Capitol 7-1404

ROCHESTER 4, NEW YORK
Locust 5250

ST. LOUIS, MISSOURI
Jackson 4-4040

SALT LAKE CITY 1, UTAH
Empire 4-3601

SAN FRANCISCO 24, CALIF.
Atwater 2-3340

SEATTLE 4, WASHINGTON
Main 3-7160

WHITING, IND. (CHICAGO)
Whiting: Whiting 826
Chicago: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd.
Toronto, Ont., 1110 Birchmount Rd., Scarborough, Phone: Plymouth 73246

Montreal, P.Q., 1400 Norman St., Lachine, Phone: Melrose 7-3591

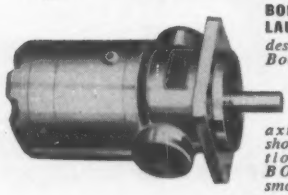
Circle 443 on Page 19

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

Fast, smooth action and precision control with DENISON hydraulic power for missile...

HANDLING



BOMARC HYDRAULIC LAUNCHER/ERECTOR *designed and built by Boeing Airplane Co., Seattle, Washington —is powered by Denison 500 Series constant volume axial piston pump, shown in inset. Elevation of the 7½-ton BOMARC is fast, smooth, fine-line accurate with Denison hydraulic power.*

FROM STORAGE TO LAUNCH, ground handling systems equipped with Denison hydraulic components are performing complex and exacting missile handling jobs with maximum speed and precision.

The entire Denison line—pumps, motors, valves, controls—is engineered to meet today's demanding GSE requirements.

Denison hydraulic equipment is engineered for smooth, steady operation... rapid response... precision infinite regulation. Rugged, reliable, compact Denison units (in capacities from 3 to 120 gpm and pressures to 5000 psi) can help you improve new or existing ground support equipment designs.

Whatever your requirements for GSE hydraulic systems—transporter, erector, launcher or checkout equipment—call in the Denison Hydraulic Specialist near you to demonstrate how Denison equipment fits your particular application.

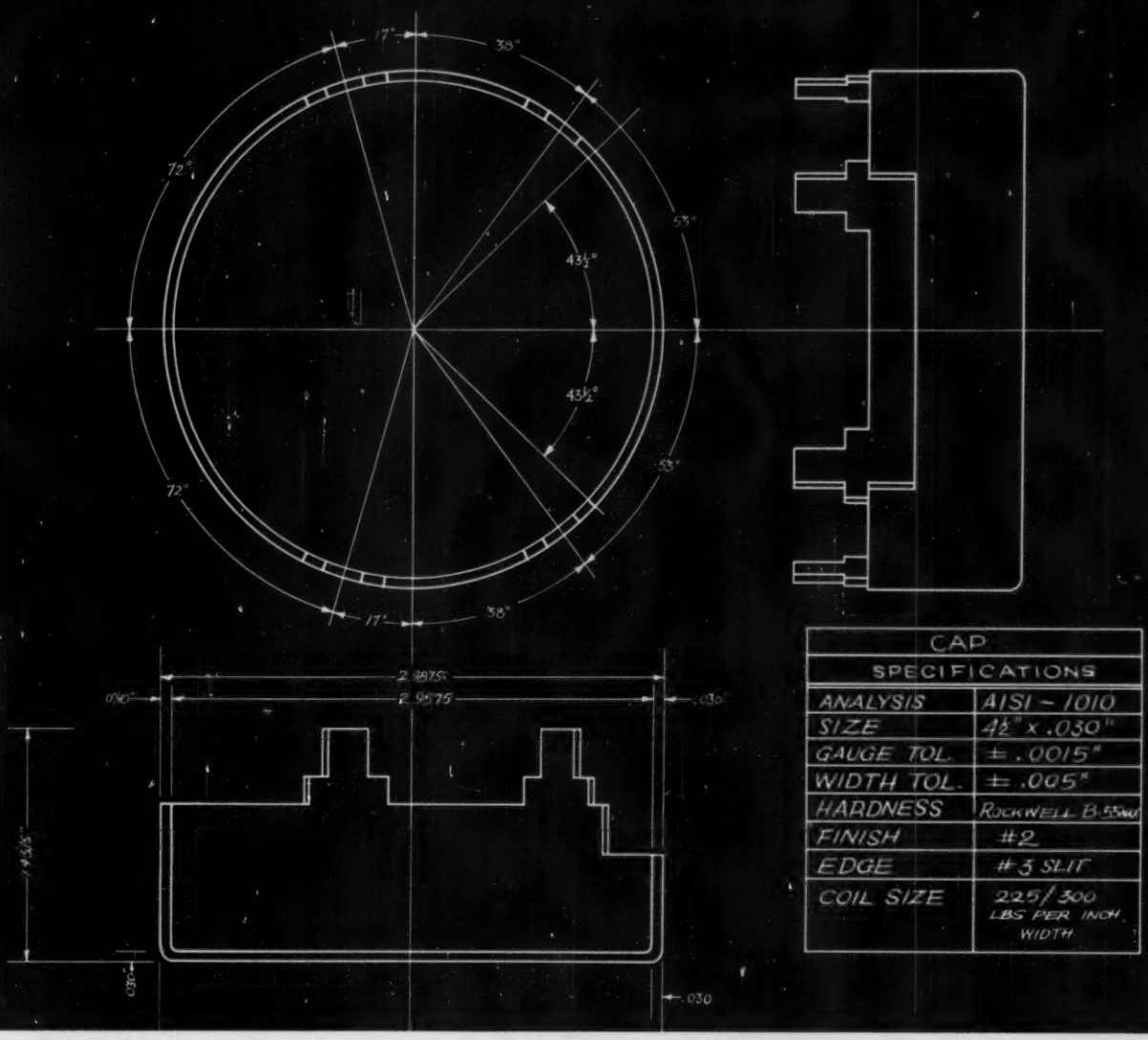
New Technical Bulletin 204 gives details on Denison "Advanced Hydraulic Components For Ground Support Equipment". Write for your copy.

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1240 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

Circle 444 on Page 19



CAP SPECIFICATIONS	
ANALYSIS	AISI – 1010
SIZE	4½" x .030"
GAUGE TOL.	± .0015"
WIDTH TOL.	± .005"
HARDNESS	ROCKWELL B 55/60
FINISH	#2
EDGE	#3 SLIT
COIL SIZE	225/300 LBS PER INCH WIDTH

HOW CLOSE SHOULD THE TOLERANCES BE HELD?

This part may be produced in a ten-stage, progressive stamping die. It will be made from 0.030″ low carbon cold rolled strip steel. The normal gauge tolerance is 0.0015″ . . . or, a total variation of 0.003″.

Is this tolerance tight enough?

Of course, tolerance should be no tighter than necessary for the successful design of the finished part . . . or for efficient, trouble-free stamping. If the part cannot be fabricated with a minimum of production trouble, the tolerance is *not* tight enough . . . regardless of the design requirements of the finished part. In an intricate, high speed stamping operation, a variation of 0.003″ could easily result in a high percentage of rejects; could cause frequent down-time . . . constant tool adjustment; could create *needless* production problems.

Why not check your own stamping operation?

Assured optimum production starts with the design specifications . . . with the specification of J&L Precision cold rolled strip steel. J&L can hold gauge tolerances to tenths of thousandths to provide steel which will perform as your design specifies . . . to deliver the maximum yield per pound of steel.

The experience, facilities and accumulated know-how of a specialized organization . . . directed exclusively to the processing of low carbon, high carbon, alloy, tempered and stainless strip steels . . . are available to work for you. For assistance in solving your problems, call your J&L Stainless and Strip Division representative, or write to Dept. 235Y-1017.

STRIP

LOW CARBON • HIGH CARBON • ALLOY • STAINLESS
TEMPERED SPRING STEEL • ZINC AND COPPER COATED

Circle 445 on Page 19

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

KODAK ANNOUNCES 3 IMPORTANT NEW

Superb, high-contrast emulsions now ON ESTAR BASE

Now you can meet the job at hand with intermediates that are as tough as they come and have exceptionally sharp detail.

Big new plus in these 3 films is Kodak's Estar Base which gives much longer life and greater dimensional stability to reproductions of drawings, maps, documents.

These new Estar Base films are highly translucent for fast "print back"... have an excellent matte surface on both sides for easier drafting . . . won't turn yellow or become brittle . . . and are resistant to moisture. Available in popular cut-sheet sizes and in rolls up to 52 inches wide.

---

1. Kodagraph Autopositive Film, ESTAR BASE
Ideal choice for general reproduction work—gives you same-size positive intermediates directly without a negative step . . . can be exposed and processed in room light. Excellent results from print-through and reflex printing—even when reflexing from metal templates.

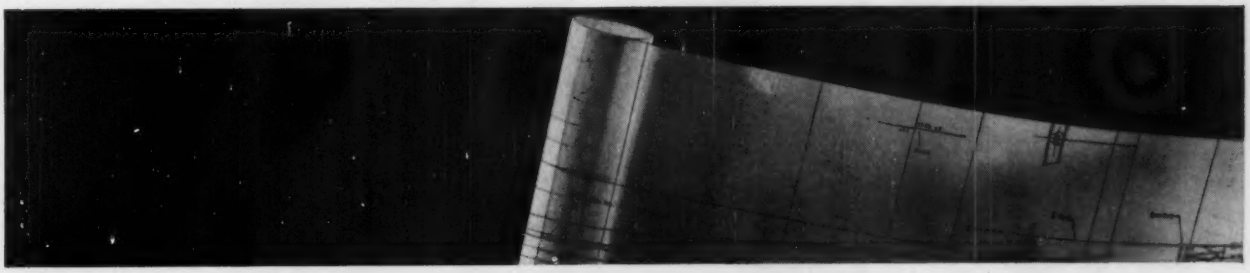
2. Kodagraph Contact Film, ESTAR BASE
Bound to be a darkroom favorite in making same-size reproductions of old or weak line drawings and other documents from film or low-cost paper negatives. Exposures are made with standard contact printers. Processing done with either paper or litho developers. Exceptionally wide latitude of this film all but ends make-overs.

3. Kodagraph Projection Film, ESTAR BASE
Changing scale is easy with this high-contrast, quick-processing film. It gives you sharp, clean results when enlarging microfilm negatives, or reducing large drawings, blueprints, maps. Can be handled with "1A" safelight, and exposed in enlargers, projection printers, process cameras.

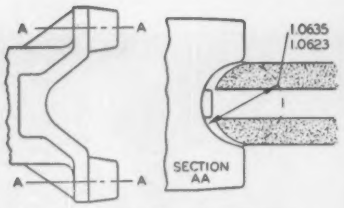
Really something every engineer, draftsman, and blueprinter should get full details on now. Call your local Kodagraph dealer for free literature, or write to Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N.Y.

NEW! Kodagraph
REPRODUCTION FILMS

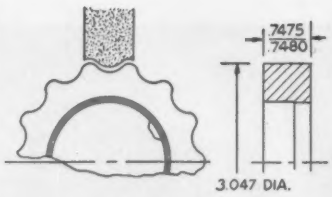
Circle 446 on Page 19



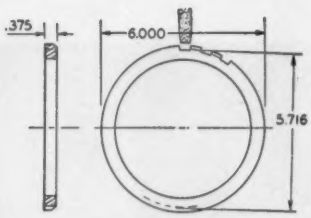
KODAGRAPH FILMS...



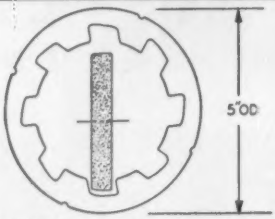
Job: Grind 2 half-rounds from rough
Part: Universal Joint
Output: 400/hr, floor to floor
Material: Pearl. Mall. Iron
Pcs/load: 10



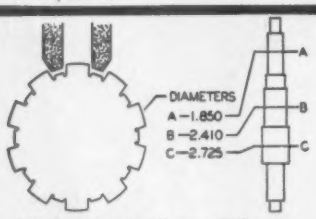
Job: Contour grind 14 lobes
Part: Pump rotor
Output: 88/hr, floor to floor
Material: Steel 200 Brinell
Pcs/load: 12



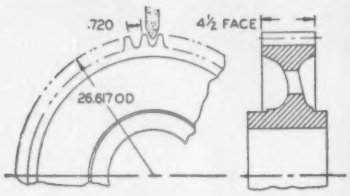
Job: Grind 24 teeth from solid
Part: Splined spacers
Output: 18/hr
Material: Steel
Pcs/load: 9



Job: Contour grind internal cams
Part: Roller clutch cam
Output: 60/hr
Material: Case hardened steel
Pcs/load: 2



Job: Straddle grind 3 sets of 10-splines (parallel sides)
Part: Transmission mainshaft
Output: 2.7/hr/spline set
Material: Steel 61-64 Rc
Pcs/load: 1

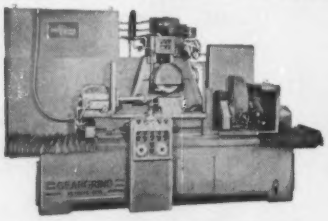


Job: Grind 94 teeth (.017" per side)
Part: Railroad gear
Output: 1.1/hr, floor to floor
Material: Steel 60 Rc
Pcs/load: 1

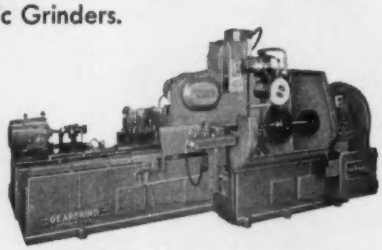
Now You Can Plan on FULLY AUTOMATIC FORM GRINDING

to cut costs, improve accuracy on external and internal contours

Here are some examples. You can do all these jobs—involute, cycloidal, spherical, etc.—at either high production or job-shop rates with top accuracy on highly versatile Detroit Automatic Grinders.

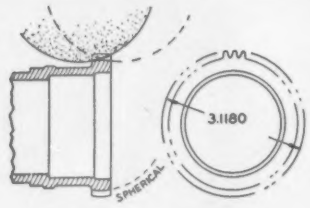


"Detroit" automatic contour grinder for up to 20" PD.

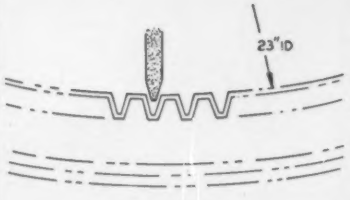


"Detroit" automatic contour grinder for up to 36" external and 30" internal.

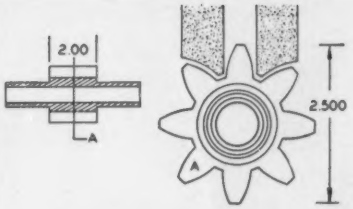
GEAR GRINDING MACHINES DIVISION
MICHIGAN TOOL COMPANY
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN



Job: Spherical grind 48 teeth
Part: Spherical gear coupling
Output: 2.3/hr
Material: Carburized 60 Rc
Pcs/load: 1



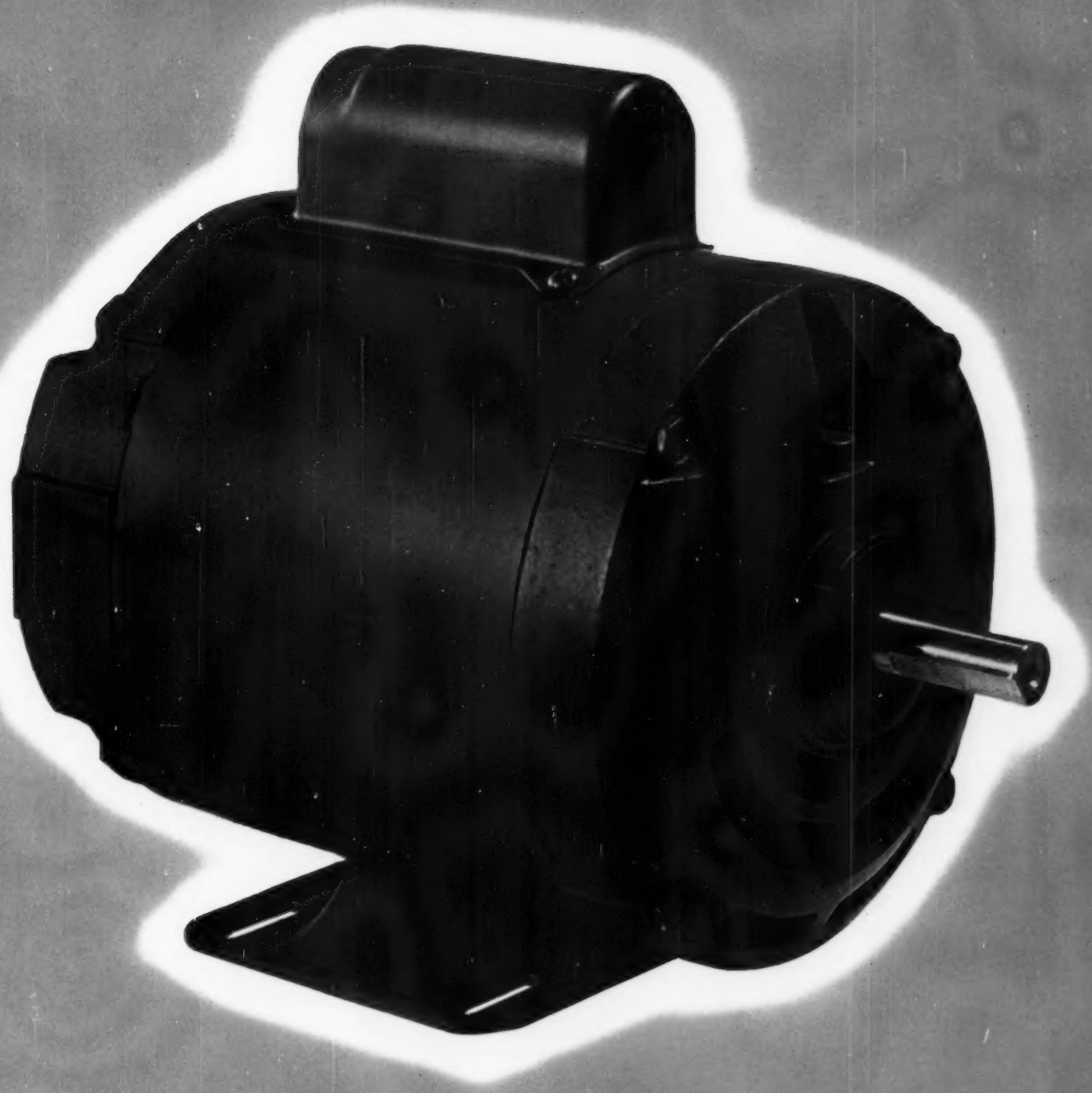
Job: Internal grind 157 teeth
Part: Aircraft reduction gear
Output: 1.2/hr
Material: Case hardened
Pcs/load: 1



Job: Straddle grind 8 teeth
Part: After-burner pump gear
Output: 11/hr, floor to floor
Material: Nitrided steel 15N-90
Pcs/load: 1

Circle 447 on Page 19

Circle 448 on Page 19→



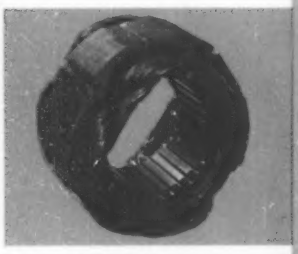
A NEW Duty Master FHP.

for heavy-duty industrial use

RELIANCE ELECTRIC AND ENGINEERING COMPANY

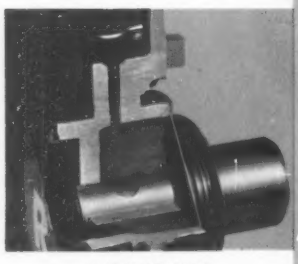
MASTER ELECTRIC COMPANY DIVISION

A NEW Duty Master FHP.

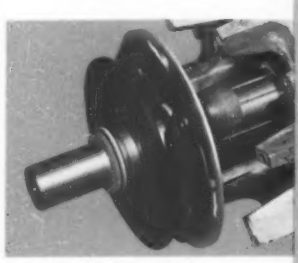


PROTECTED STATOR

TERMINAL BOARD



SLEEVE BEARING



CENTRIFUGAL CUT-OUT

TOUGH...COMPACT...COOL!

A motor that combines new, most-wanted features at no extra cost

Duty Master:

This motor is tough all over . . . deliberately designed for heavy industrial duty. Frame is rolled from steel—end shields cast from an aluminum alloy specifically selected for strength. Ball bearings are double-shielded, with lubricant packed into the bearing for life. Sleeve bearings are steel-backed and babbitt-lined for low friction and long wear. "Permawick" oil retaining material provides maximum lubrication to these bearings. Rotor is pressure-cast from high purity, low-resistance aluminum. Varnish impregnated stator resists moisture . . . and adds strength to windings.

Duty Master:

More power per pound . . . simple installation, 33% lighter than other preceding motor designs. Good design and materials make the difference. Makers of motor-driven products save on shipping and handling costs. Duty Master's light weight and small size make possible lighter, less complex mounting on equipment. Terminal board provides easy power connection in the front end shield. Cover plate quickly removable. Motor rotation easily reversed by interchanging slip-on connections.

Duty Master:

Up to 10% cooler than other comparably rated motors . . . yet gives you maximum protection. High load capacity results from new, effective ventilation of critical heat sources. Laminations, coils and rotor are literally rinsed with cooling air through new end shield design. In totally-enclosed, non-ventilated motors, the fan, cast integrally with rotor, circulates the air within the motor at a rate appropriate to efficient transfer of heat to motor frame and end shield. And load carrying capacity of the totally-enclosed fan-cooled motor is increased by a fan and shroud directing air over the frame and end shield.

Duty Master:

Quiet . . . Smooth . . . Positive. Resilient mounting composed of metal-rimmed, rubber-cushioning rings that encircle the bearing hubs on each end and support the motor. Motor can be mounted in any position. Single phase starter winding circuit automatically opens at 80% of full load speed. Action is quiet and positive.

Available now in 48 and 56 frame sizes, from conveniently located stocks. Duty Master FHP. is made in ⅛, ⅙, ¼, ⅓, ½ and ¾ hp. capacitor-start, split-phase and polyphase for 48 and 56 frames; repulsion-start induction-run in 56 frame. Your Reliance Sales Engineer or Distributor has all the facts at his finger tips. Call him or write for Bulletin B-2514. It will be sent to you promptly. B-1075

PRINTED IN U.S.A.

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

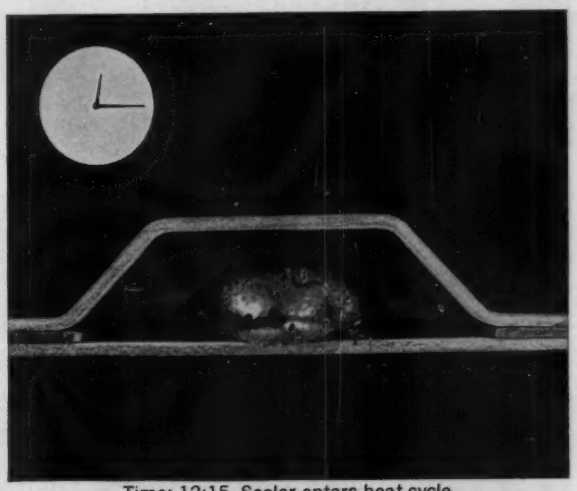
CLEVELAND 17, OHIO

Canadian Division: Toronto, Ontario

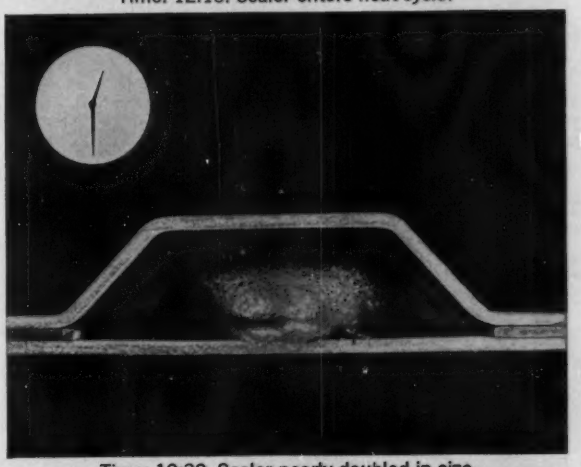
Sales Offices and Distributors in principal cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

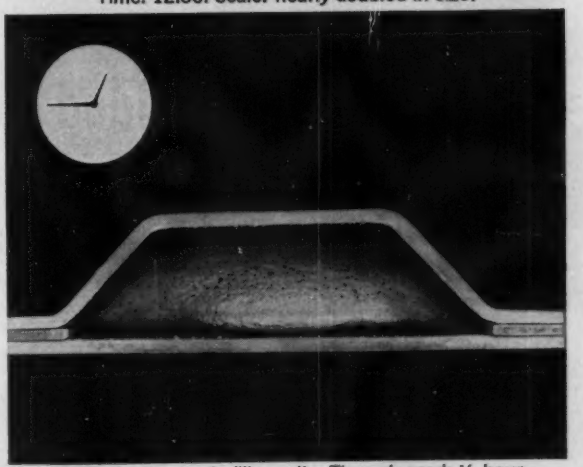
Positive way to seal irregular gaps and seams—3M Heat Expandable Sealers



Time: 12:15. Sealer enters heat cycle.



Time: 12:30. Sealer nearly doubled in size.



12:45. Sealer nearly fills cavity. Time elapsed: ½ hour.

You can simplify tough sealing jobs of irregular gaps and seams with 3M Heat Expandable Sealer EC-2117. When heated this liquid will expand 150% in volume and cure to a solid sponge rubber material to tightly fit the shape of the seam, affording a weather-tight, water-tight, dirt-tight seal.

EC-2117 is designed to expand and cure to a resilient sponge-like rubber which will adhere to most surfaces. It can also function as a weld-thru sealer which does not alter normal spot welding procedure, nor interfere with weld quality. EC-2117 adheres well to both clean and oily surfaces. Use it wherever irregular openings must be filled, or where seam width is not constant.

Let 3M Adhesives, Coatings and Sealers help speed your production, improve product quality. For free information, write on your company letterhead to: AC&S Division, 3M Company, Dept. SBR-100, St. Paul 6, Minnesota.

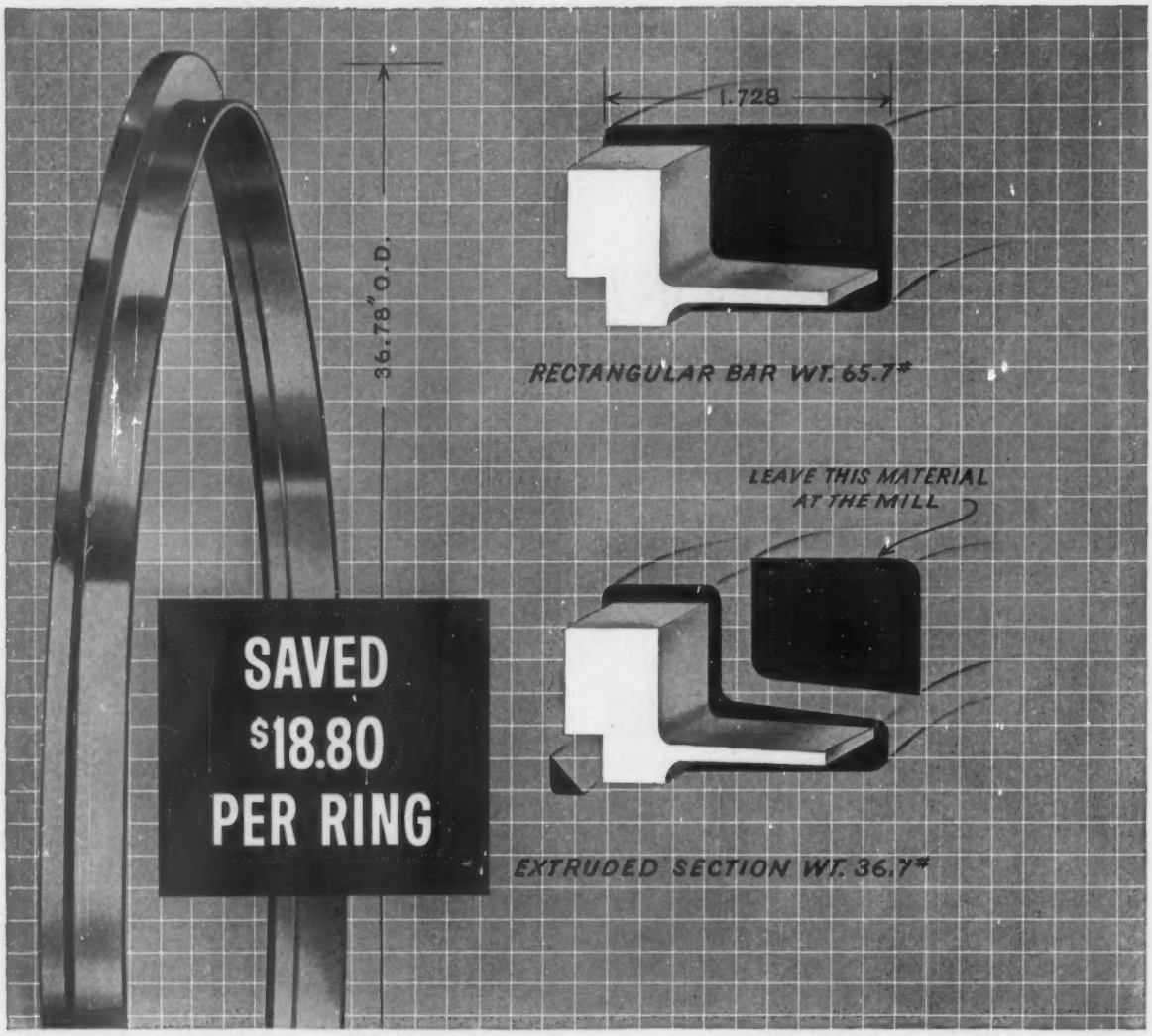
ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Circle 449 on Page 19



Flash butt-welded rings cut the amount of stainless 321 required by 50%

Using a special extruded section, 29 lbs. of stainless 321 were eliminated —plus the extra hours of expensive machining required to hog it out.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and complete machining facilities, phone or write.

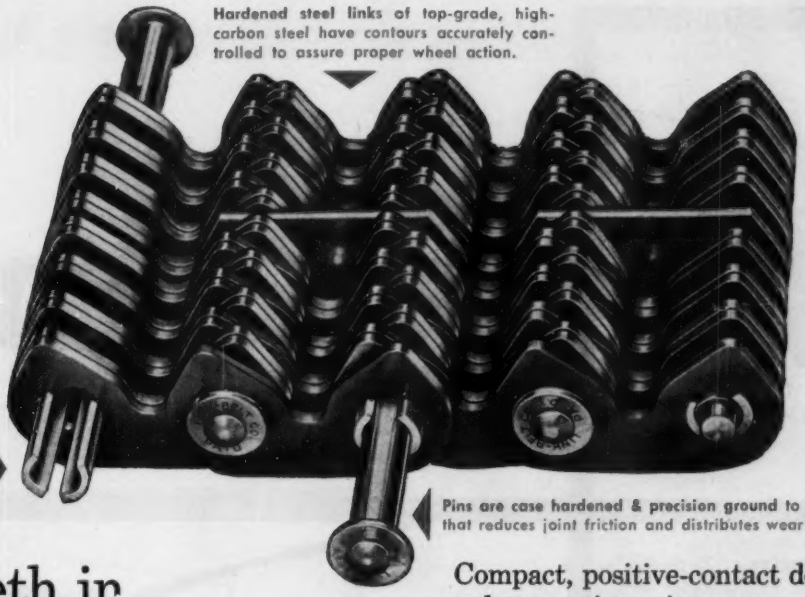
GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

Circle 450 on Page 19


Hardened steel links of top-grade, high-carbon steel have contours accurately controlled to assure proper wheel action.
Bushings of specially selected steel are case hardened to take joint wear and prevent elongation of link hole.
Pins are case hardened & precision ground to permit free rotation that reduces joint friction and distributes wear over entire surface.

The teeth in Link-Belt silent chain put the bite on drive costs

Compact, positive-contact design reduces entire unit expense

There are big savings to be found by switching to modern, versatile Link-Belt silent chain drives. Smooth, positive engagement prevents slippage, eliminating wasted horsepower. Long life—continuous operation with minimum maintenance for many years is common—keeps production costs down.

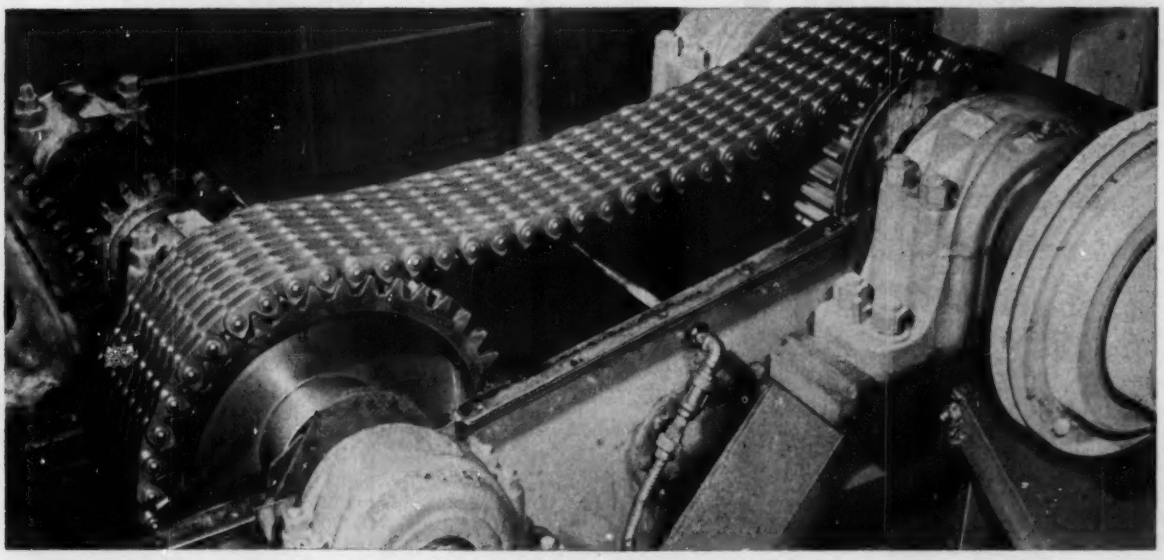
Now consider these additional advantages: dependable operation under extremes of temperature and humidity; easy assembly in tight spaces, permitting built-in drives, compact housings; space saving and efficiency on extremely short centers at ratios as high as 10-to-1.

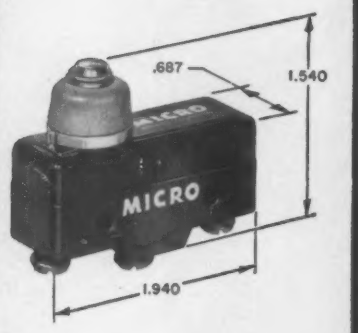
Link-Belt silent chain is available in a full range of types and sizes for either large or fractional-horsepower drives. For full details, call your nearby Link-Belt office. Look under CHAINS in the yellow pages of your phone book. Ask for Book 2425.

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

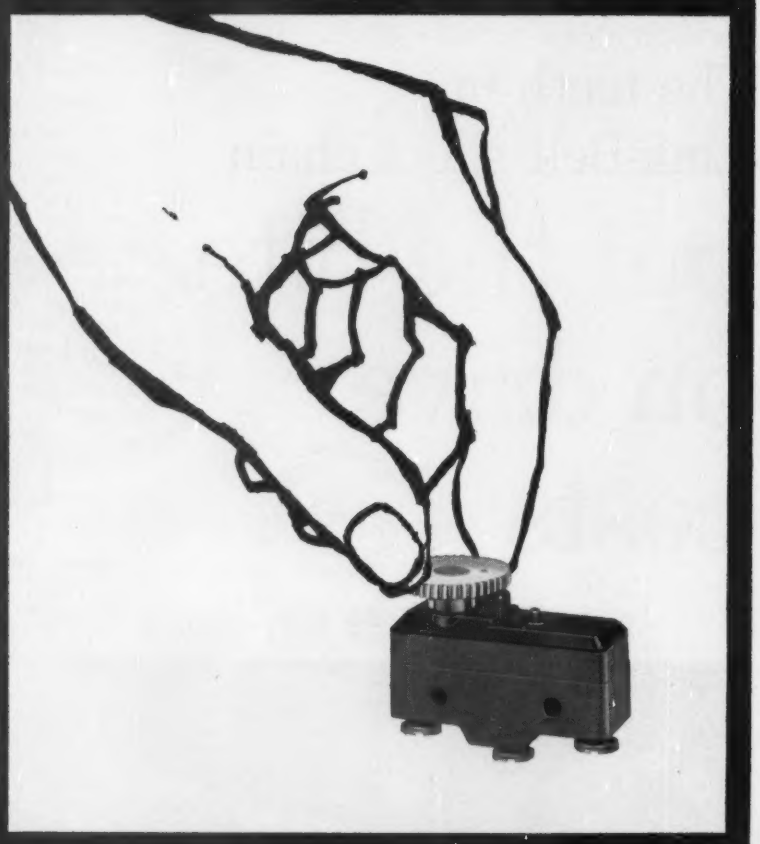
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 18,450



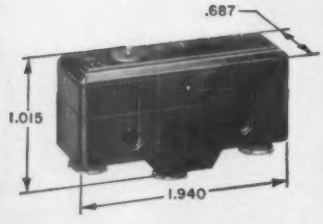


SWITCH NEWS FROM MICRO

Sealed Basic Switch. Type "Z" sealed switches have an elastomer boot around the plunger actuator and a cement seal around the cover, preventing moisture and foreign matter from entering the switching chamber. They are rated at 15 amperes, 125, 250, or 480 vac. Seven different actuator designs are available to accommodate various operating methods. Write for Catalog 62.



New 25-Ampere Switch. New "E" Series basic switches are UL listed for 25-ampere service at 125/250 vac. Ability to handle 75-ampere inrush currents makes them especially useful with solenoids, motors and heaters. Available in eight different actuator designs and four terminal types. Write for new Data Sheet 181.



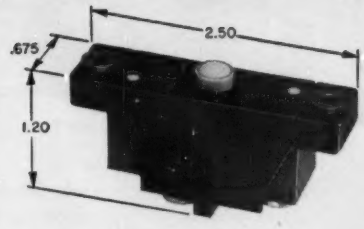
New Adjustable "Differential Travel" Switch. A turn of the dial on this "10BS" Series switch varies its differential travel characteristic between 0.0025 and 0.007 inch. Designed for use as the precision switching element in sensitive control applications, it permits fine adjustment of the control's on-off cycling characteristics. Typical applications include pressure controls and blower fan controls. Contact arrangement is single-pole double-throw. Write for new Data Sheet 179.

75 YEAR HONEYWELL ENGINEERING THE FUTURE

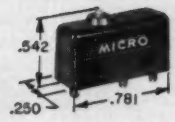
MICRO SWITCH Precision Switches

SWITCH

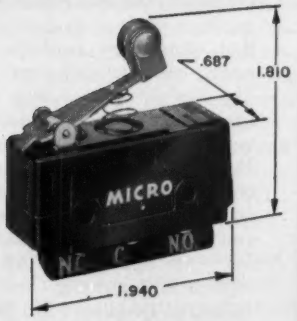
basic switch designs for precise, reliable control



Machine Tool Basic Switch. "3 MN" Series switches are designed for use with limit, sequence or control mechanisms on machine tools, presses and other industrial equipment. Single-pole two-circuit double-break contact arrangement permits a variety of wiring combinations. Its narrow width facilitates gang-mounting, while its unique terminal design eliminates the need for insulating barriers. Median mechanical life exceeds 10,000,000 operations at full overtravel. Write for Catalog 62.



New High Sensitivity Subminiature Switch. This "SM400" Series switch has a differential movement of only 0.001 inch max., without sacrifice of electrical rating or performance. An ideal switching element for pressure and temperature controls and other devices where ultimate control sensitivity or response is mandatory. It is also ideal where only a minute motion is available, or very low energy differential is a requirement. Rating is 5 amperes at 125/250 vac. Write for Data Sheet 180.



Double-Pole Double-Throw Switch. "DT" Series switches simultaneously make and break two independent circuits, providing a normally open and a normally closed contact with each pole for several different wiring combinations. Seven integral actuator versions are available. Write for Catalog 62.

Prompt engineering help on switch problems is readily available by simply calling the nearby MICRO SWITCH Branch Office listed in the Yellow Pages.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

Design Data on Resilient Clutch Facings

8

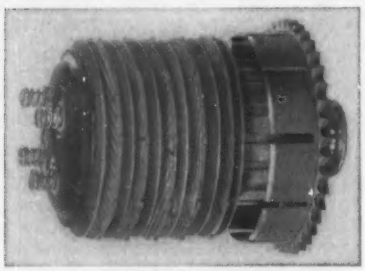
SOME CLUTCH PROBLEMS SOLVED BY RESILIENT FACINGS

Eliminating Clutch Burn-Out

The clutch in a Triumph motorcycle gets a workout in road races. It has to engage quickly at speed differentials as high as 4000 rpm at full throttle as many as 20 times a minute. The clutch plates are splash lubricated with oil at an ambient temperature of 250° F. Under these severe conditions, clutch burn-out was a constant problem.

After testing many materials, engineers selected Armstrong NC-733, a cork-and-rubber facing. They found that NC-733 engaged quickly, reducing the slippage that builds up heat and destroys facings.

Triumph has eliminated clutch burn-out and gained a competitive speed advantage by adopting NC-733 for all heavy-duty clutches.

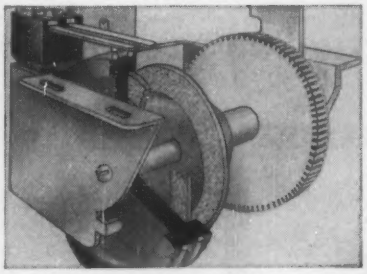


Triumph Motorcycle Clutch

Improving Instrument Accuracy

Leeds and Northrup potentiometer-type industrial recording and control instruments depend for their accuracy upon standardizing mechanism in which a rheostat compensates for declining battery voltage. The rheostat has a friction facing which is engaged by a friction-faced drive gear.

Since random motion would ruin accuracy, the facing must engage instantly and positively under only 28 ounces of closing force and then break away cleanly. The facing also must slip for a short time when the rheostat reaches the end of its travel.



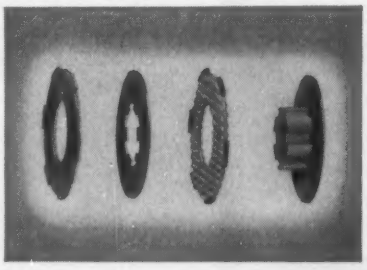
L. & N. Recording Potentiometer Clutch

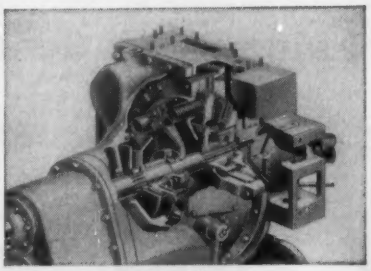
An Armstrong facing keeps the Leeds and Northrup recorder more than 99½% accurate. And there is no wear from slippage, so neither facing ever has to be replaced.

Simplifying Clutch Design

Three Armstrong facings deliver the same torque capacity as the eight metal plates previously used in this automatic washer clutch, cutting fabrication and assembly costs significantly. The switch to resilient facings solved both a production and a maintenance problem. The old clutch with metal plates required a half-hour break-in period plus an oil drain and refill operation. In spite of this precaution, metal particles continued to damage gears and facings, causing failure in service. Now, the use of resilient facings has cut out the break-in run and, more important, the facings last the life of the appliance.

Automatic Washer Clutch





Caterpillar Motor Grader Clutch

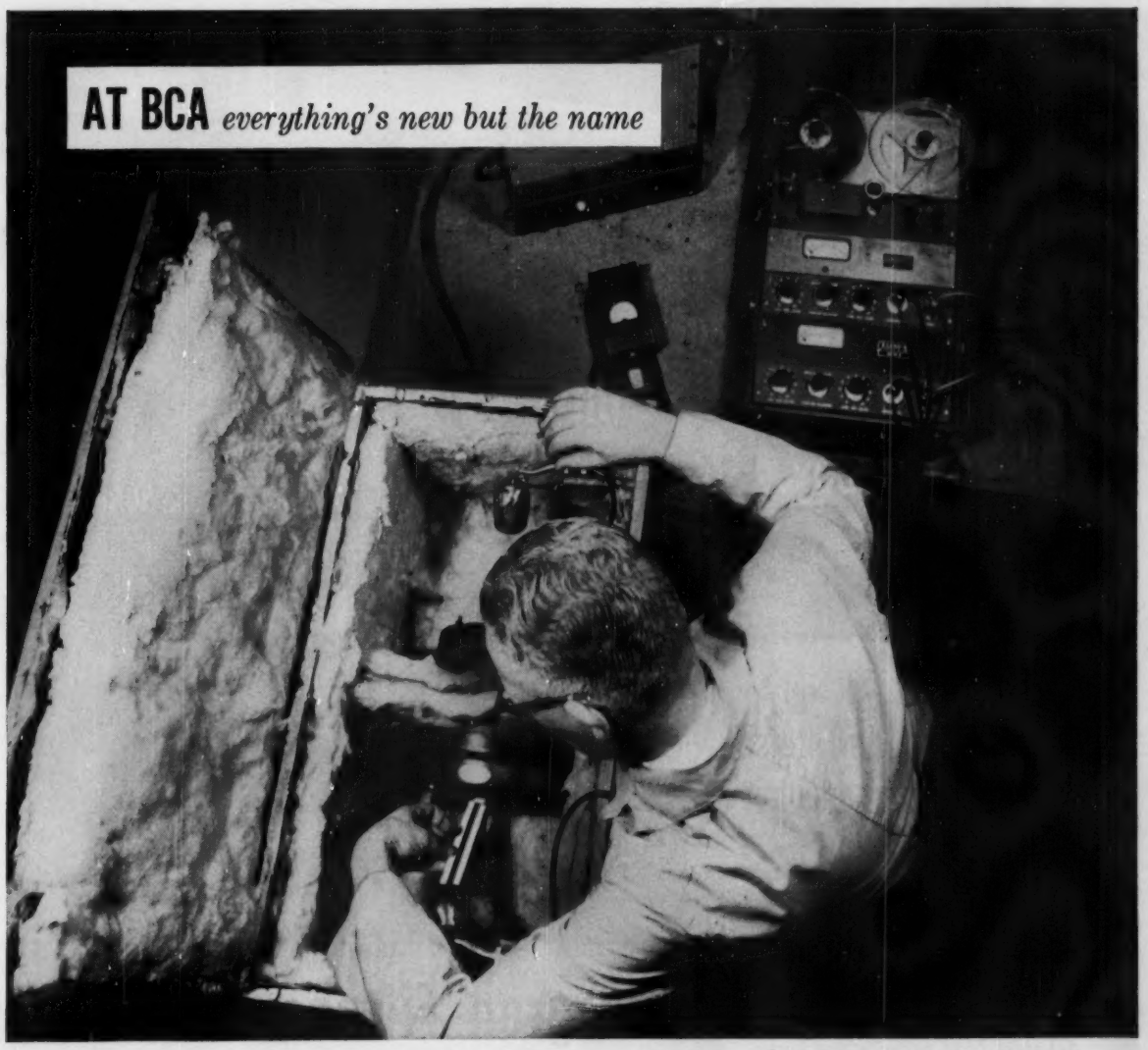
Increasing Clutch Life

In heavy construction work, this motor grader clutch has to engage as often as 20 times a minute, transmitting 375 ft-lbs of torque. The facings of the dry clutch wore down rapidly, making frequent adjustments and replacements necessary. Caterpillar engineers converted to an oil-filled clutch using an Armstrong resilient facing. This Armstrong friction material provides as much torque capacity when coated with oil as the original clutch facing did dry — eliminating the need for more plates, bigger plates, or higher engagement pressure. The new clutch with Armstrong resilient facings lasts five to ten times longer and requires no adjustments for facing wear.

Clutch designers are using resilient facings more widely today than ever before. Recent advances in compounding have opened up new applications that were once restricted to more costly, less efficient materials. If you'd like complete information on how to use these versatile materials, write for your free copy of "Resilient Friction Materials." This new 44-page manual contains charts, graphs, and performance data plus a check sheet to help you select the right friction material for your application. Address your request to Armstrong Cork Company, Industrial Division, 7210 Dean Street, Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

1860-1960 Beginning our second century of progress



NEW POLYPHONIC ANALYZER

probes ball bearing noise in electric motors

In the double-celled acoustic chamber above, electric motor bearings are analyzed under operational conditions. An electric motor is run inside the split, acoustically-insulated chamber. In each cell, sound from the running motor is picked up by sensitive microphones, measured for noise level, then tape-recorded stereophonically. When the stereo tapes are played back and analyzed for frequency content, it's possible to pinpoint the cause and source of noise in a motor, and to eliminate it through design changes in either the bearings or the motor itself.

This BCA-developed bearing research tool is being used to test bearings . . . evaluate bearing lubricant formulations . . . check the value of varying metal combinations . . . determine ideal surface finish and contour of bearing raceways and balls.

In the Temperature-Humidity-Controlled Instrumentation Room at BCA, this and other specially designed devices test BCA bearings for use under conditions *often identical to operating conditions specified by the customer.* The result: BCA bearings which meet or exceed performance specifications on the equipment for which they are designed.

There's a complete BCA line of ball bearing sizes and types for almost every kind of industry . . . automotive, earth-moving, agricultural, for example. This, plus BCA's extensive new research, testing and production facilities, assure bearing users of a dependable source of durable ball bearings to meet almost any need. For information, write Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

Circle 453 on Page 19

The most efficient compressed-air-line filter you can buy...

New, perfected-design Norgren Air-Line Filters give you these benefits:

1. Complete liquid removal.
2. Highly effective removal of solids.
3. Choice of 4 interchangeable filter elements to best suit your requirements—5, 25, 64, 74 microns.
4. New, stronger transparent bowl.
5. Larger bowl capacity and larger quiet zone for trapping collected liquid.
6. Improved baffle design prevents return of liquid to air line.
7. Quick, easy cleaning—no tools needed—only 4 parts to handle.

Where safety regulations require protection for bowls *from external physical damage—a removable metal bowl guard is available.*

Founded in 1926

C. A. NORGREN CO.

3442 SOUTH ELATI STREET
ENGLEWOOD, COLORADO

Norgren Filter removes all liquid from compressed air

The improved design of the new line of Norgren Filters provides a greater than ever liquid removal efficiency—removing all liquids over the entire range of recommended air flow. Removal of abrasive solid particles is also highly effective.

New, stronger transparent bowl is an important feature of the new filters. This bowl has a higher safety factor than ever before and a much greater resistance to fatigue.

The bowl has a larger capacity for collected liquid. The "quiet zone" below the baffle holds 53% more collected air-line contaminants—requires less frequent draining.

Servicing is easier and quicker. No tools are required to disassemble the filter for cleaning, and there are only four separate parts to handle.

For complete information about the money-saving features of the Norgren complete line of manual drain and automatic-drain filters, call your nearby Norgren Representative, listed in your telephone directory—or **WRITE FOR BROCHURE NA-1.**

WANTED

the toughest wear problem known for

CARMET CARBIDE

• the hardest metal known •

*****If you've got a real wear problem, it's time you take a long, hard look at Carmet Cemented Carbides . . . and how they can extend operational life and reduce costs.

Carmet Cemented Carbides possess the perfect combination of extreme hardness, strength, and abrasion resistance for the battering that wear parts must take . . . the rubbing, scrubbing, sliding, and scraping.

Carmet Cemented Carbides have a compressive strength higher than any metal or alloy . . . cast, rolled, or forged. They are the hardest man-made metal . . . next to a diamond in hardness, yet far tougher . . . three times stiffer than steel, and up to 100 times more abrasion resistant.

And you can put this hardness and wear resistance where it will do the most good. Carmet wear parts can be made in practically any shape . . . adapted to any function.

For all the facts on carbide wear parts, get Carmet's new booklet on design for wear resistance. It's packed with charts, graphs, case histories, and special design criteria for top wear parts performance. Ask your local A-L representative for a copy, or write: *Allegheny Ludlum Steel Corporation, Carmet Division, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept. MD-10-2.*

1095

CARMET® AL

CEMENTED CARBIDE • DIVISION OF ALLEGHENY LUDLUM

Circle 455 on Page 19

For parts DIRECT from machining to assembly.. dependably

NO HEAT TREATING REQUIRED with

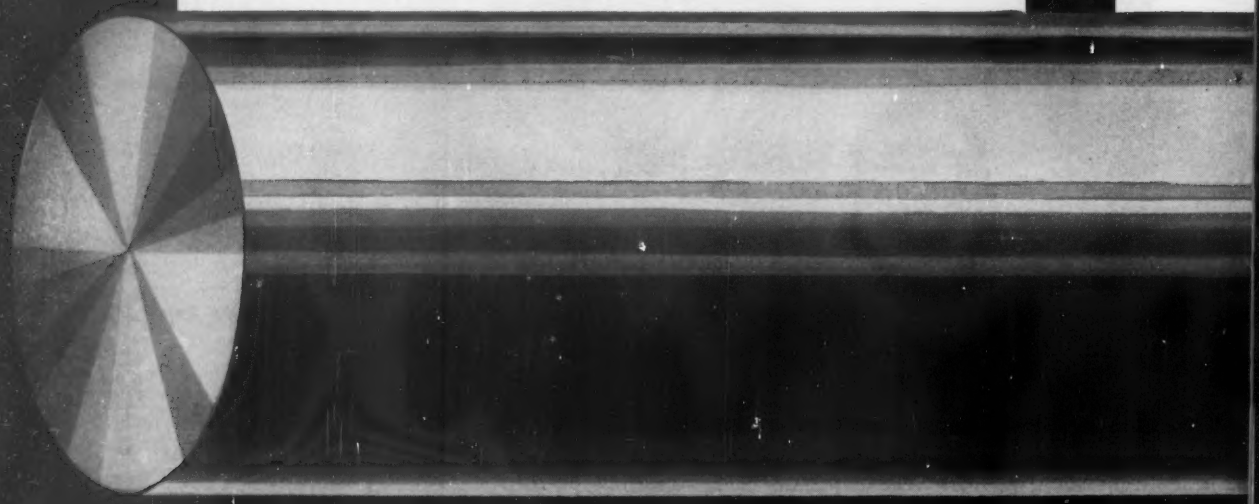
La Salle e.t.d. 150

elevated temperature drawing

ALLOY STEEL BARS

GUARANTEED 150,000 PSI tensile strength

- **e.t.d. 150 alloy machines better than heat treated in-the-bar alloy steels!**
- **e.t.d. 150 alloy has exceptional uniformity!**
- **e.t.d. 150 alloy simplifies production!**



Quality and Cost-reducing Advantages!

(1) Heat treating with its attendant costs and hazards is eliminated. (2) No quench cracks or distortion due to heat treating. (3) Machinability is greatly improved by the acicular pearlitic-ferritic structure. (4) Tool life and finish are excellent. (5) Production is simplified . . . secondary operations following heat treat are eliminated. (6) Part quality, uniformity and reliability are maintained or improved. (7) End cost is greatly reduced.

Ask for a sample test bar

Send a blueprint . . . or write us giving application details.

What is e.t.d. 150 alloy?

"e.t.d." 150 is an alloy steel bar made by the exclusive and patented Elevated Temperature Drawing process to a guaranteed minimum tensile strength of 150,000 psi and a hardness of Rc 32 minimum. Strength and hardness are uniform across the section of the bar. The uniform pearlitic-ferritic structure of "e.t.d." 150 alloy eliminates the problems associated with non-uniform quenched and tempered structure. Ideal for shafts, gears, pinions, fasteners and other parts now being heat treated or made from heat treated in-the-bar materials.

SPECIFICATIONS

Ultimate Tensile Strength	150,000 psi minimum*
Yield Strength (.2% offset)	130,000 psi minimum*
Proof Stress (.01% offset) (1½" Rd. and smaller only)	120,000 psi minimum*
Elongation—Approx. only	10% -20%
Reduction of Area—Approx. only	35% -45%
Brinell Hardness Number	302 minimum*
Rockwell "C" Hardness	32 minimum*

*GUARANTEED MINIMUMS. In event of disagreement between hardness and tensile strength, the tensile strength shall govern.

Use this coupon to ask for helpful data bulletin

La Salle STEEL CO.
1426 150th Street
Hammond, Indiana

Please send Helpful Data Bulletin No. 22, "e.t.d. 150 alloy steel bars eliminate heat treating of parts."

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

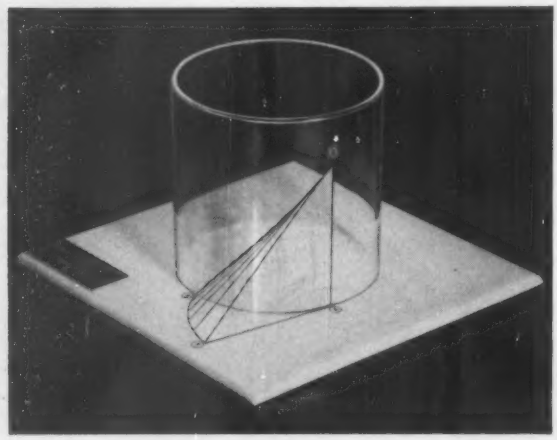
Circle 456 on Page 19

WORM GEARING

Why the INVOLUTE HELICOID thread form?

Introduction of involute helicoid worms by Delroyd marks the first time extensive use of this design has occurred in America. Therefore the question arises: "What is the involute helicoid worm and what are its advantages?"

Basically an involute helicoid worm is the same as an involute helical gear. However, this similarity is not easily recognized because of the difference in angle of thread or



tooth helixes in the two types. Regardless of the difference in helix angles, both types have an involute thread or tooth profile in the transverse plane, i.e., a plane perpendicular to the axis.

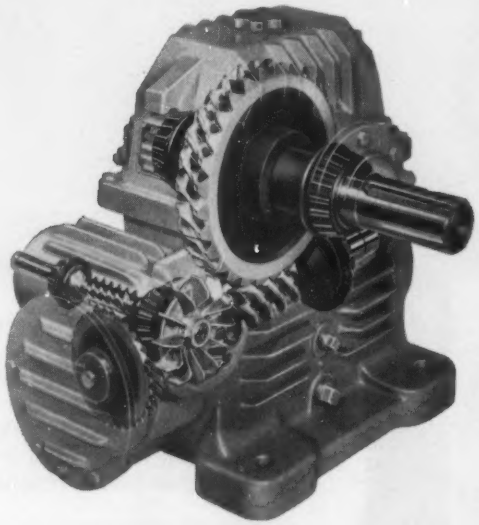
The thread surface is made up of a series of involute curves lying in transverse planes. The thread flank generating edge is a straight line tracing out a helical path (see illustration). Manufacturing *simplicity* of generating and checking to straight line form control provides consistent production of worm and generating hobs of high *accuracy*. Deviation from the straight line in checking *hundreds* of worms in one production lot can be held to within a few *ten* thousandths of an inch.

The easy and accurate attainment of *exact similarity* between worm and hob provides complete compatibility of worm to gear without manufacturing process interruptions to modify and change hob form. Form does not change as hobs are sharpened. Accurate interchangeability is an undisputed fact.

Only the involute helicoid worm form permits practical application of calculable compensating features for gear deflection under load. All gears have leaving side contact with entering side gap to form beneficial oil wedge. Kinematically accurate tooth meshing avoids the acceleration and deceleration inevitable with other forms.

Superior performance is the result, since this form outperforms all others. Size for size, the DELROYD involute helicoid worm form offers a higher selection safety factor with no premium cost.

For further information on DELROYD worm gearing, write on your company letterhead for our new 84-page catalog, the most comprehensive in the industry.



DE LAVAL STEAM TURBINE COMPANY

858 NOTTINGHAM WAY, TRENTON 2, N. J.

DL-201

Before Buying Any Valve

ASK THESE QUESTIONS

1. Will It Perform More Effectively In The Service?
2. Where Will It Save Money?
3. How Practical Is The Design?

jamesbury "Double-Seal"™ BALL VALVES*

As Versatile As Industry Itself!

PROVIDE THE RIGHT ANSWERS

1. The "Double-Seal" Ball Valve has PROVED more effective in handling a wider range of liquids and gases than any other valve.
2. The "Double-Seal" Ball Valve requires no lubrication. Special design permits valve stem to be removed for repacking while valve remains in line full-open or full-closed. Resulting savings on maintenance are significant.
3. The "Double-Seal" Ball Valve design is the original ball valve design engineered to give more control, full pipeline capacity and minimum friction loss.

JAMESBURY CORP., Worcester, Mass.

Distributors in Principal Cities

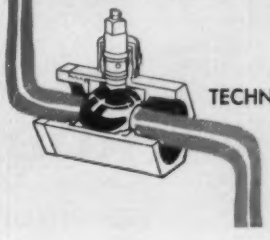
Widest Range of Sizes and Materials Available

METAL VALVES		PLASTIC VALVES	
TYPE	SIZES	TYPE	SIZES
Screwed End	¼" thru 3"	Screwed End	½" thru 3"
Flanged	½" thru 10"	Flanged	½" thru 4"

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Hypalon and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.



COMPLETE TECHNICAL INFORMATION ON REQUEST

* PATENTED

3134

Circle 457 on Page 19

this R & M motor puts the "Drive" in IBM electric typewriters!

Almost twelve years have elapsed since International Business Machines Corporation used its first R&M motor to power its electric typewriters. Since then R&M has supplied thousands upon thousands of these special motors for IBM's world-wide typewriter trade. In order to meet varying electrical conditions the world over, they are now supplied in 21 different voltages and frequencies.

IBM proposed strict requirements for powering their machine. The motor must have high starting torque for quick response . . . run very quietly . . . cooler than normal . . . fit a limited space . . . and have stamina to perform dependably year after year. Within a short period of time, R&M delivered specifications for the right design—a dynamically balanced motor that fulfilled all of IBM's standards, including reliable operation that covers thousands of hours between check-ups.

A lot of fingers have gone over the keys since R&M produced its first IBM typewriter motor, but we still subject each IBM power unit to 100% inspection. Moreover, we constantly work with IBM—and all our customers—to improve our motors and to adapt them to the ever-changing requirements of customers' products.

R&M's experience in custom-designing motors for hundreds of products, and our facilities to produce a design at low cost, are at your service. Perhaps your problem can be met with a standard *"off-the-shelf"* power unit. If so, we'll tell you . . . and recommend the right R&M motor for the job. For power by either custom or standard fractional HP motors . . . and performance that will give you a big competitive advantage . . . get in touch with Robbins & Myers today! Write for Bulletin No. 450-MD

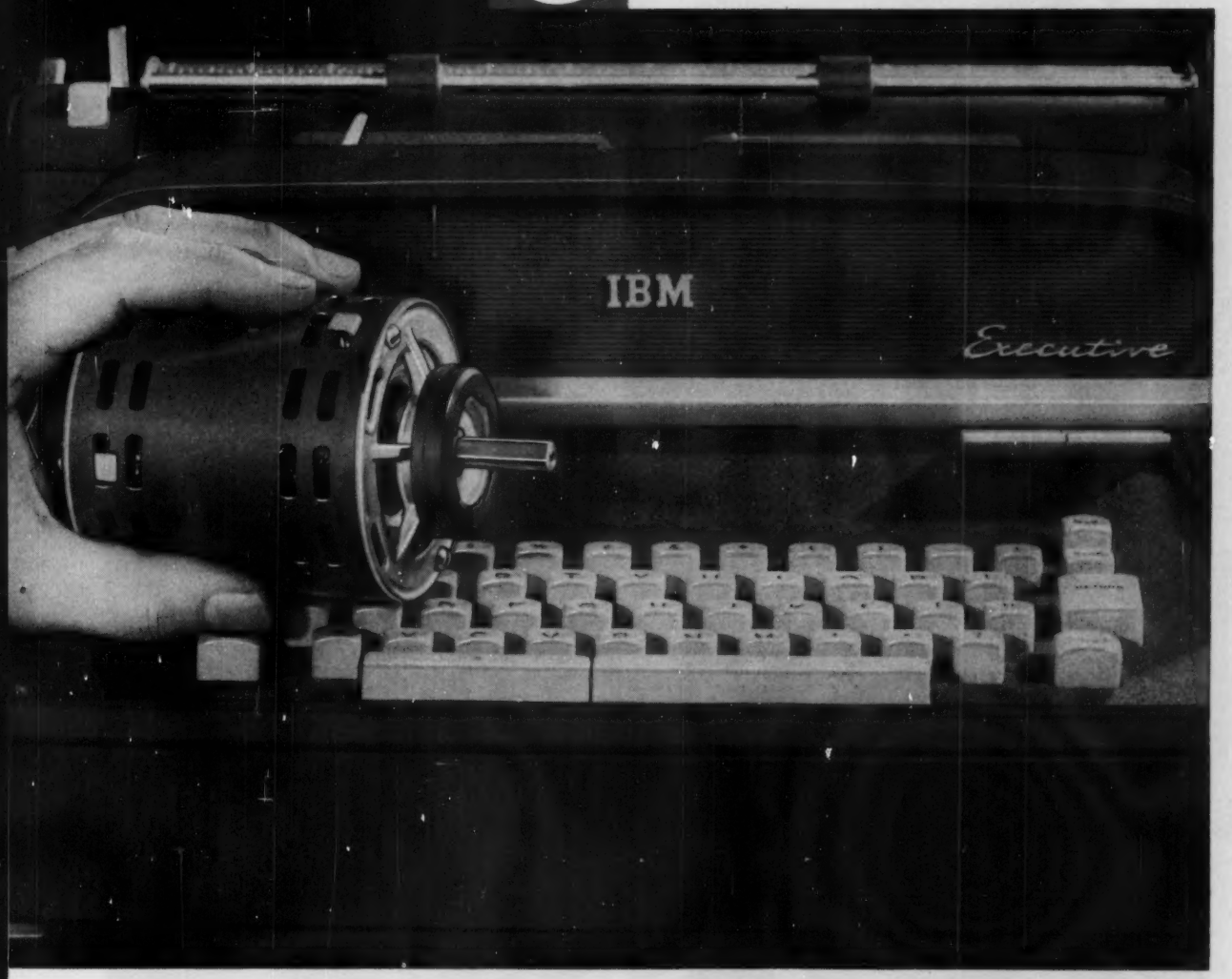
ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

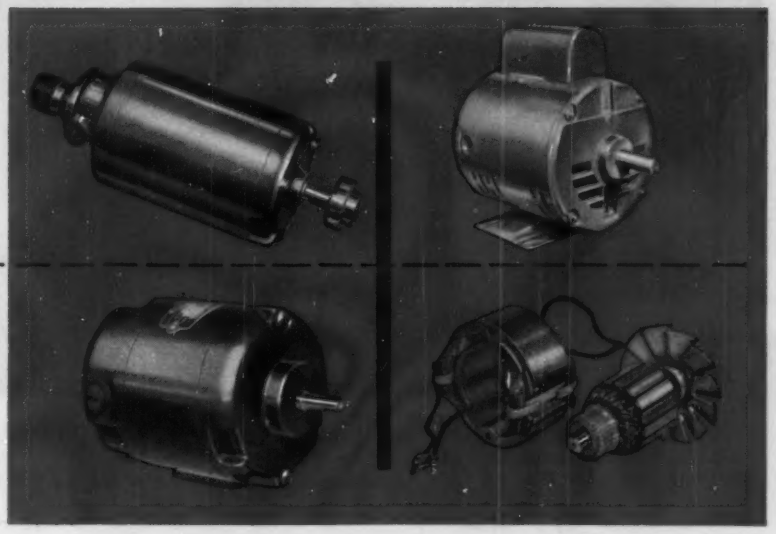
MOTORS 1/200 thru 1 HP

(other ratings up to 200 horsepower)



At left, Retractable Capstan Motor . . . shaft of this special R&M fractional HP motor rotates and also moves axially. Manufactured for IBM's 727 Magnetic Tape Unit.

At right, Standard Fractional HP Motors . . . a wide range of types, sizes and mountings for DC, single or polyphase AC; all standard voltages and frequencies.



At left, Standard Universal Motors . . . ratings from 1/60 to 1/2 HP. Choice of end, pad or foot mountings to permit design versatility. Custom designs also available.

At right, Series Motor Parts . . . precision-made series, universal or polyphase high-cycle motor parts. All types and sizes engineered to your requirements.

Circle 458 on Page 19

Pick a Number!

There are only four basic numbers in Fenwal's new "500" Line of Electronic Temperature Controllers and Indicators. But they provide industry with a broad choice of instrumentation *not available elsewhere!*

For example, a packaging machine manufacturer might have the problem of controlling 6 heater blocks on a unit capable of sealing a variety of films. He'd want separate control of each block — 3 "ON-OFF" and 3 proportioning — with remote adjustment of control. The Fenwal 536 Controller would give him all this. For indication during periodic checks, he'd simply add the 580 Indicator. *Price? Extremely reasonable!*

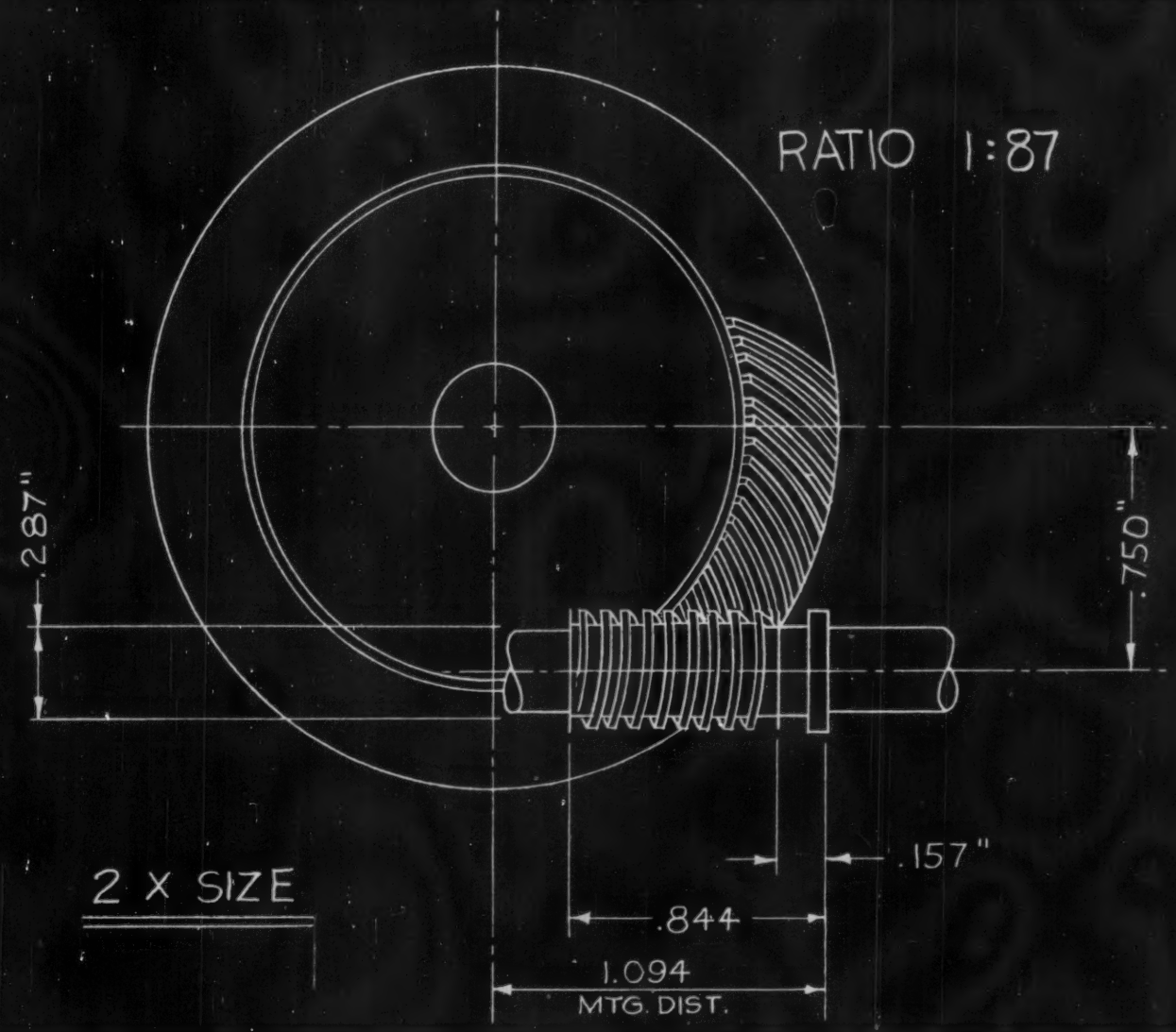
Again, a soap manufacturer might want either "ON-OFF" or proportioning control of four batch process tanks in separate plant areas — with control and indication at each point. He'd choose the Fenwal 561 Indicating Controller — a *stock unit.* He'd have no mounting problems. And with thermistor sensors, use ordinary lead wire to the supervisory panel. *As simple as that!*

Another manufacturer whose needs are only indication, might select the 582 Thermometer. And there are many *modifications* and *combinations* possible. Why not make *your* choice from these "Smarter Looking Smarter Acting" Fenwal Instruments? Write for Bulletin MC-190. FENWAL INCORPORATED, 1912 Pleasant Street, Ashland, Massachusetts.

Another example of how

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

Circle 459 on Page 19



HERE'S ANOTHER GEAR GLEASON BUILT FROM FIRST DESIGN TO FINAL PRODUCT

This is the finished prototype of a new high-ratio hypoid gear. Our customer will now produce it, royalty free, on his Gleason equipment.

This is but one example of what Gleason engineering service can do for people who need gears. Our facilities and advice are at your constant disposal for development of bevel and hypoid gears to meet the needs of any application.

This particular high-ratio pair (actual size shown in insert) offers several advantages over conventional gears:

GREATER STRENGTH. High-ratio hypoid pinions are larger and stronger than corresponding bevel pinions.

COMPACTNESS. Where space is a problem, the high-offset principle lets you design a more compact and flexible unit than the corresponding worm and wheel.

SMOOTHER ACTION. High-offset pairs provide smooth, quiet tooth action . . . *continuous* action even with only one or two teeth, because of the way the teeth wrap around the pinion.

STRADDLE MOUNTINGS. Cylindrical high-ratio pinions, with extended shank, make practical very rigid straddle mountings.

GRINDING. High reduction hypoids are cut on same Gleason equipment used on familiar bevel and hypoid gears. Same testers, quenchers and other auxiliary equipment can be used. Grinders are available for the ultimate in precision and finish to minimize friction.

LET GLEASON MAKE RECOMMENDATIONS. Send along a set of prints, and we'll be glad to study them and give you our thoughts on how best to make the gears you need.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Circle 460 on Page 19

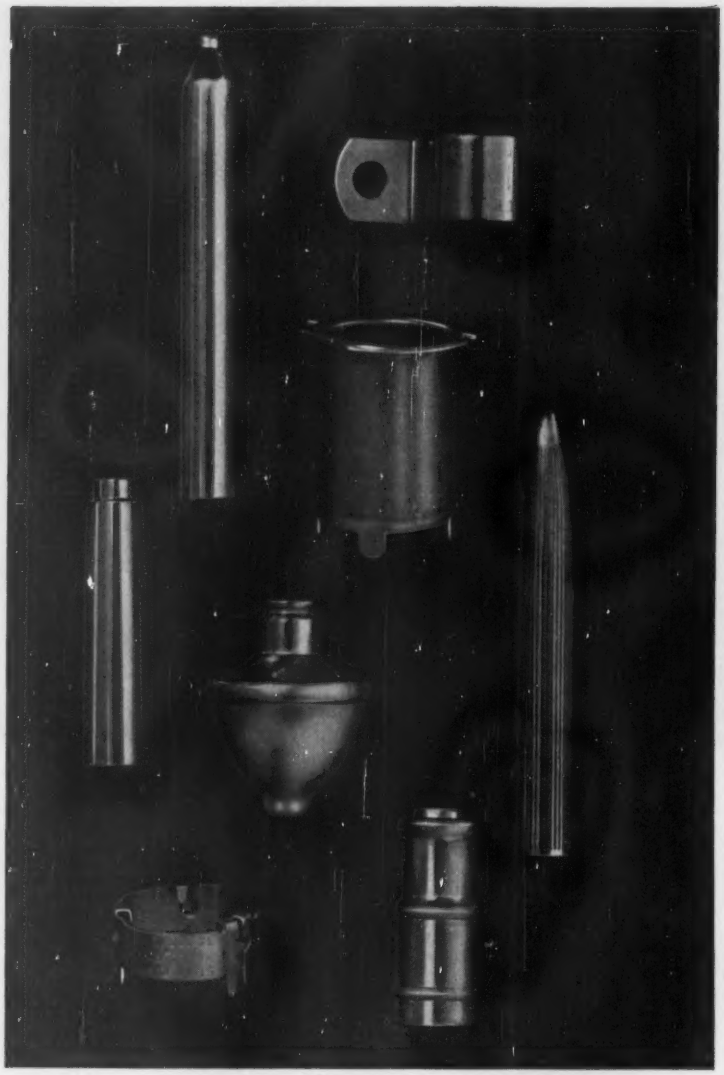
IF YOU NEED CUSTOM PARTS

Sylvania offers complete QC* service

Helps you with completely objective recommendations for your parts. Sylvania is backed by long experience in metals, plastics, welds and assemblies; can produce parts utilizing a wide range of automatic and semiautomatic equipment.

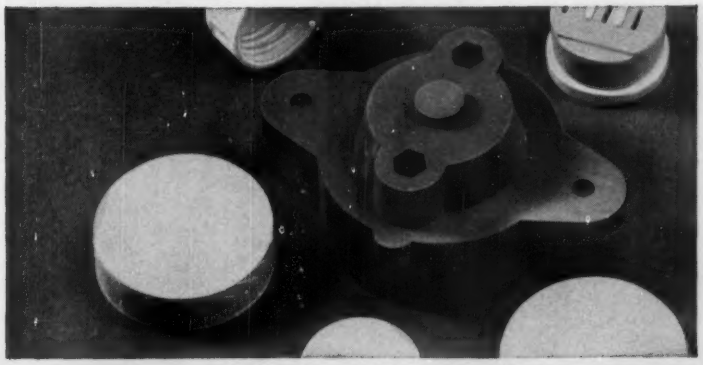
Offers design assistance that can often improve the quality of your part, and lower production costs.

Provides superior quality parts. Sylvania utilizes the most modern equipment available, and its experience in tooling means better quality at lower costs for finished parts. In addition, Sylvania preventive maintenance for dies and equipment assures you precise uniformity, uninterrupted production.



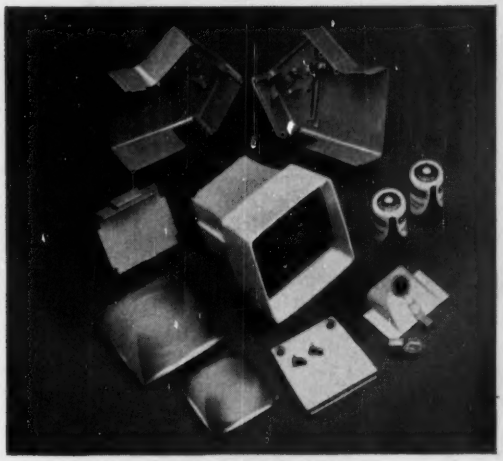
FORMED FROM METAL

Sylvania can supply the parts you need—in the desired high production quantities—to the most exacting specifications—at lower costs. If your part is a deep-drawn eyelet, shell, cup or ferrule—Sylvania has already gained long experience in this field producing millions of fountain pen caps, curtain rod ends, etc. And if it can best be produced by four-slide equipment, Sylvania has produced millions of contacts, retainer clips, electrodes, etc. What's more, vertical press equipment and special Sylvania-developed machines also can produce great quantities of small and medium-size parts to meet your needs daily.



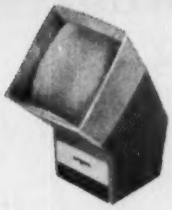
MOLDED FROM PLASTICS

Sylvania maintains one of the world's most complete lines of modern automatic molding equipment for compression, injection and transfer molding. Example: a bank of rotary presses ideally suited to phenolics and urea. These presses can produce millions of parts each day and assure you efficient, quick and low-cost plastic parts in volume.



CUSTOM WELDED

Whether your part is standard-sized, miniature or subminiature, welded assembly is a Sylvania specialty. To help meet your custom welding needs, Sylvania has developed new high-speed, high-volume welding techniques, advanced welding equipment (automatic and semiautomatic) and a corps of trained custom-welding specialists. Result: Sylvania welds assure better electrical and mechanical contact, mirror-image uniformity, low cost.



CUSTOM ASSEMBLED

Many of our customers have analyzed their parts assembly requirements. And they have found Sylvania can often deliver a completely assembled and packaged product—using either all Sylvania components, all customer components or both—at lower cost than is possible within the customer's own facilities.
Result: If your product is small, the parts predominantly plastic and metal, and the quantities 50,000 or more, it pays you to have Sylvania trained specialists assemble it.

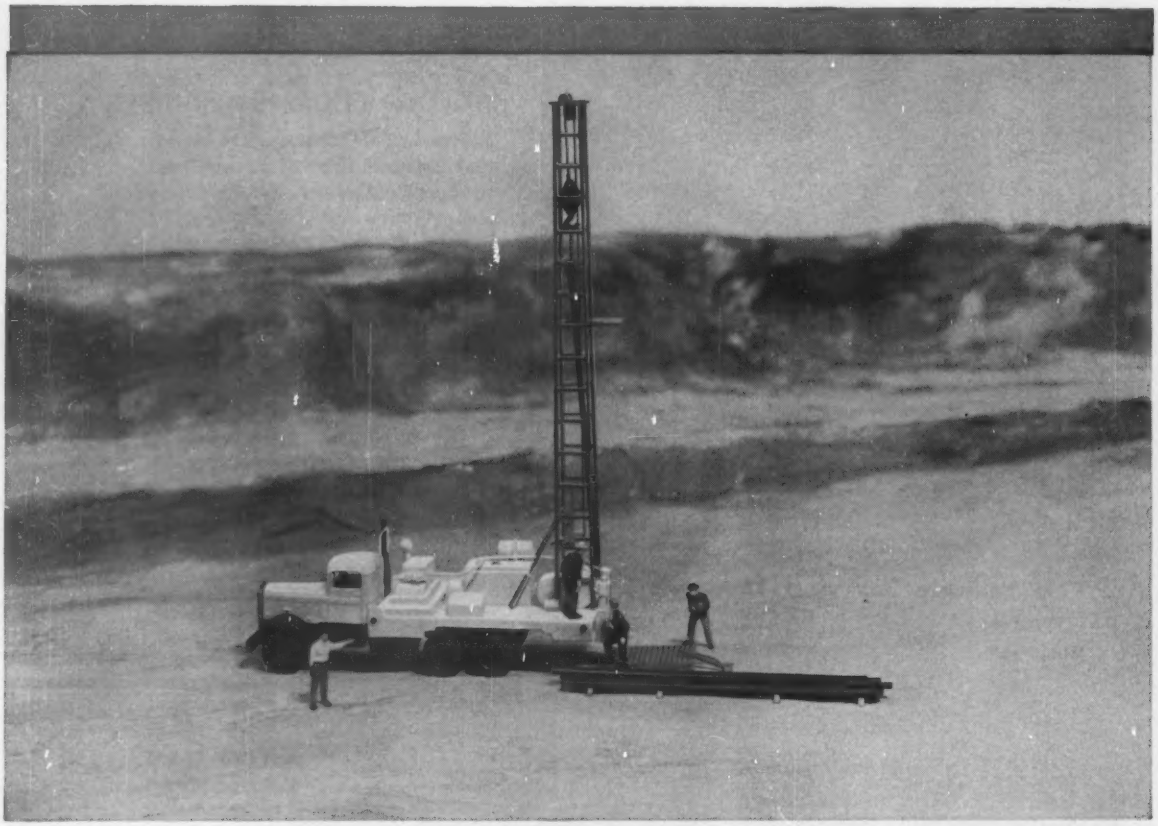
*QC MEANS QUALITY CONTROL!

Sylvania maintains a complete quality control department to assure that parts are made to your exact specifications for each component. This control works for you throughout the manufacturing cycle. It's just one more way you benefit when you put Sylvania on the job for parts.
For full details or a quote, write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

Circle 461 on Page 19



Down-to-earth reasons for using Custom Quality OHIO Tubing

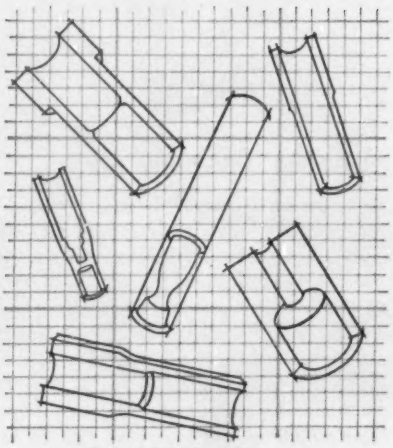
As in rotary drilling, which uses steel tubing internally upset by Ohio Seamless, greater strength and lighter weight may be important in your product.

So before selecting a tubing source consider these important facts. OHIO Tubing is always the exact tubing you need for your product because OHIO Tubing is CUSTOM MADE for your product. Your order is manufactured to your own specifications to produce steel tubing especially for your application — the precise grade, analysis, size, shape, special anneal and tolerances best suited to your needs.

Ohio Seamless Tube produces both seamless and electric welded steel tubing — is prepared to form many finished or semi-finished tubular parts to your designs.

To get the most from your next steel tubing order, use Custom Made OHIO Tubing. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America. A-3061A

Model illustrated built to 3.5 mm scale.



Typical Ohio Seamless tubular upset forgings

OHIO

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**

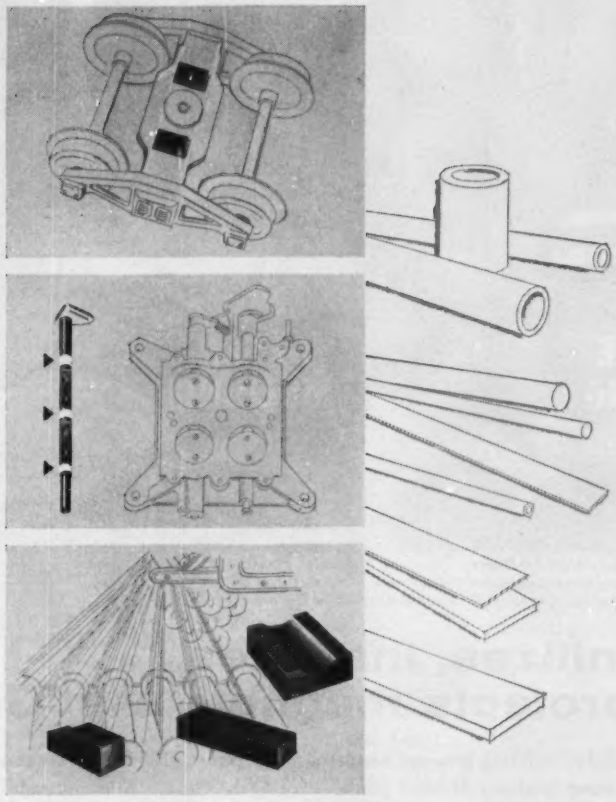
Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Kansas City, Los Angeles (Lynwood), Miami, Moline, New York, New Orleans (Chalmette), Philadelphia (Wynnewood), Pittsburgh, Richmond, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita

CANADA: Railway & Power Engr. Corp., Ltd. • EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

NEW TEFLON BEARINGS

for Non-lubricated Service



Railroad truck bearings (top), carburetor bearings (center), and saddle bearings for textile machinery (bottom)—fabricated from top-quality Teflon* stock by Garlock—offer performance unmatched by any other material.

Now—new bearings of Teflon eliminate lubrication . . . resist extreme temperatures and reactive chemicals . . . drastically reduce downtime.

No finer combination of properties. Bearings of Teflon offer a lower coefficient of friction than any other solid material; they have exceptional thermal stability and are suitable for continuous service to +500°F; they are completely resistant to nearly all chemicals and solvents; they are tough, abrasion-resistant, have no moisture absorption.

Applied where safety and reliability are essential. Teflon is used as journal and thrust bearings, and on other sliding surfaces where lubricated bearings are undesirable, or incapable of operation in extreme temperatures or corrosive conditions, or where there is a possibility of lubricant failure. Teflon bearings afford unexcelled performance where slip-stick motion must be minimized . . . on reciprocating and oscillating systems where the lowest possible static friction must be attained . . . where space and weight savings are essential.

Easily fabricated from high-quality Garlock stock shapes. Teflon bearings can be simply and economically made from standard Garlock tape, bar and rod stock available through local Garlock distributor outlets. Or, if you wish, Garlock will work to your exact specifications in furnishing bearings of all tolerances and size. Whatever the case, the key to best bearing performance is through the use of Teflon stock shapes by Garlock. With years of experience in research and processing of plastics, Garlock is able to recommend and furnish *exactly* what you need, when you need it, and at the lowest possible cost.

Find out more about Teflon bearings. Consult your local Garlock representative at the nearest of the 26 Garlock sales offices and warehouses throughout the U.S. and Canada.

Or, write for Plastics Catalog AD-177, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

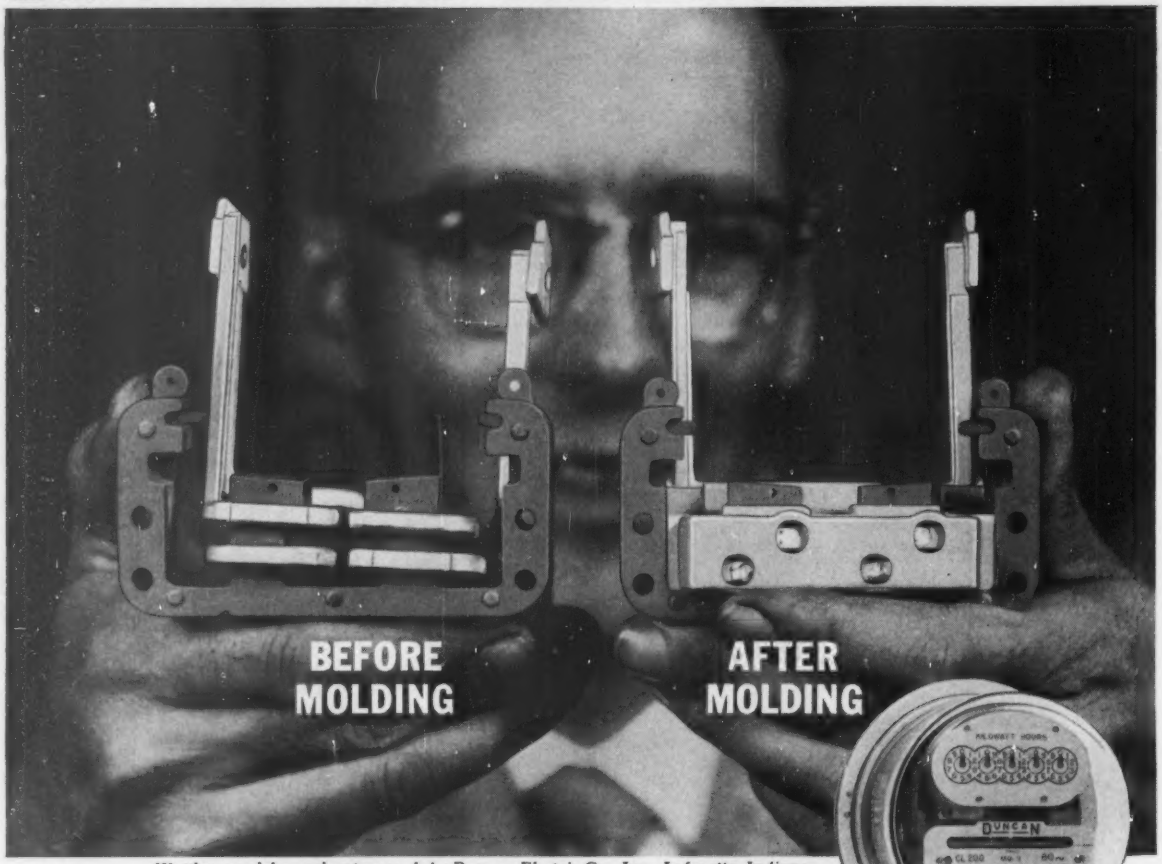
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

*DuPont Trademark

Circle 463 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



Watthour and demand meters made by Duncan Electric Co., Inc., Lafayette, Indiana, use a casing of Geon vinyl for current-electromagnet assembly injection-molded in place. B.F.Goodrich Chemical Company supplies the Geon vinyl.

Meter maker unitizes, insulates, and protects magnets with Geon

Geon vinyl does a three-way job for this meter manufacturer. By securing parts in position, providing insulation and protecting them against injury, Geon helps produce a better, longer lasting current-electromagnet assembly.

The manufacturer says that Geon exhibits excellent heat stabilization –it holds up well under high temperatures without exuding fumes that might corrode brass parts used in other areas of the meter. In addition, use of Geon made possible a less critical molding process, resulting in a more uniform finished piece.

Immediately after the molding process, high voltage tests of 7500 volts are made from turn to turn and from turn to ground—proof again of the outstanding electrical properties of Geon vinyl.

Here's another example of the way that products can be improved with Geon. Why many manufacturers are using it to open whole new markets. To get more information, write Dept. GW-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Geon VINYLS

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

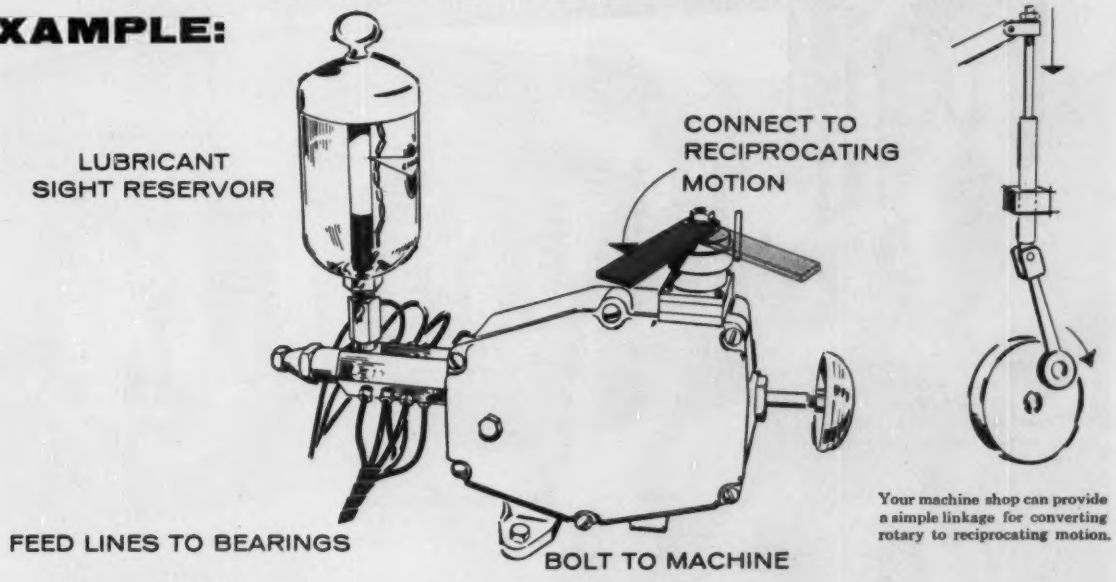
Circle 464 on Page 19

DESIGN TIPS...on automatic lubrication

PROBLEM: Lubricate machine tool automatically without using electricity or compressed air

SOLUTION: Harness reciprocating or rotary motion for positive displacement lubrication with Lincoln's ratchet Multi-Luber*

EXAMPLE:



Your machine shop can provide a simple linkage for converting rotary to reciprocating motion.

You can harness reciprocating or rotary motion on your light machine tools to provide power for automatic lubrication with Lincoln's new ratchet-operated Multi-Luber. As little as .52" straight-line motion will drive the worm gear that cycles lubricant through the Multi-Luber outlet ports to bearings.

Three operating ratios of worm gear reduction (100:1, 50:1, and 25:1) are available to satisfy requirements for any application. With standard setting, the Multi-Luber discharges 0.002 ounces of lubricant from each port every time it cycles. Output of the first four ports can be doubled.

The ratchet Multi-Luber can overcome 2000 psi back pressure while operating. It handles light grease as well as oil and delivers an accurately-measured, predetermined amount of lubricant to individual bearings. One ratchet Multi-Luber will feed from seven to 12 lubrication points. For more than 12 points, you can use additional Multi-Luber units.

Simple to hook up, the ratchet Multi-Luber is the most versatile lubrication device available. For instance, two ratchet Multi-Luber units could be mounted on a 15-bearing machine—one to dispense grease and the other oil. Install it in any position convenient for linking the drive arm to a consistently moving part.

NOTE TO MANUFACTURERS:
Lincoln assists manufacturers in adapting automatic lubrication to either new or in-plant machines. For OEM production, contact Lincoln's Original Equipment Sales Division. For in-plant applications, contact the Industrial Sales Division.

Trade Mark Registered

LINCOLN ENGINEERING CO. Original Equipment Sales Division
5736 Natural Bridge St. Louis 20, Mo.

- ☐ Please send me operating data sheets on the ratchet Multi-Luber.
- ☐ Please send Catalog 50 (Multi-Luber).
- ☐ Please send Catalog 81 (Industrial Power Lubrication Systems).
- ☐ Have your representative call to advise me regarding adaptation of the Multi-Luber to my machine.

NAME_____ TITLE_____

COMPANY_____

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1063

LINCOLN ST LOUIS

LINCOLN
ENGINEERING COMPANY

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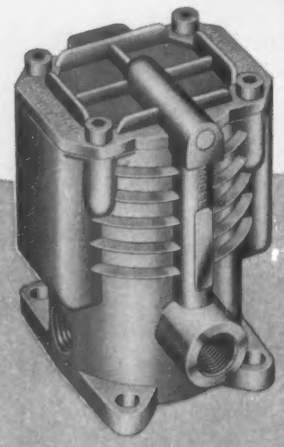
Circle 465 on Page 19

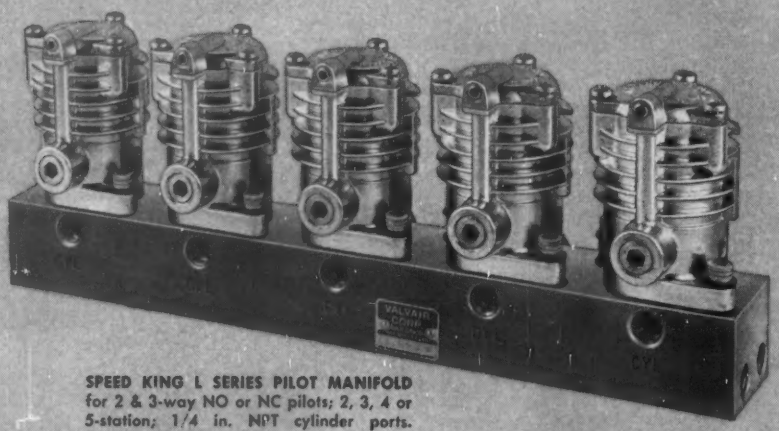
for dependable, economical control,
specify versatile...

SPEED KING®

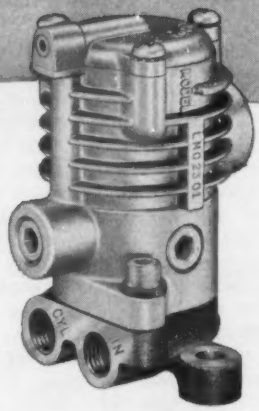
SOLENOID PILOTS



SPEED KING P SERIES PILOT 2 & 3-way NO & NC, 4-way; foot, sub-base or manifold mounting; 1/8 or 3/16 in. orifices. Foot mounting shown.



SPEED KING L SERIES PILOT MANIFOLD for 2 & 3-way NO or NC pilots; 2, 3, 4 or 5-station; 1/4 in. NPT cylinder ports. 5-station shown.



SPEED KING L SERIES PILOT 2 & 3-way NO & NC; foot, sub-base on manifold mounting; 1/16 to 1/8 in. orifices. Sub-base mounting shown.

Compact Valvair® SPEED KING pilots are ideal for control of small air or vacuum-operated devices including cylinders up to 3 in. bore, as well as for piloting larger valves. Featuring Valvair's flow-thru cooling design, they offer multi-million cycle dependability, with solenoid coils guaranteed against burn-out for the life of the valve. Choose from a full range of types, mounting styles and sizes; integral junction boxes (L Series only) and manual over-ride optional; coils for ac or dc, any voltage.

Solve your small unit control problems with SPEED KING solenoid pilots. Your Valvair or Bellows Field Engineer can recommend a size and type exactly suited to your requirements.

Bellows-Valvair
AKRON 9, OHIO
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

CONTROLLED · AIR · POWER DEVICES
Bellows-Valvair
FOR FASTER · SAFER · BETTER PRODUCTION

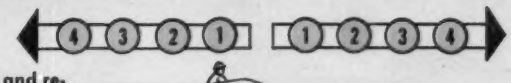
Write for free Bulletin PIL. Address: Bellows-Valvair, Akron 9, Ohio. Dept. MD-1060.

8112-3

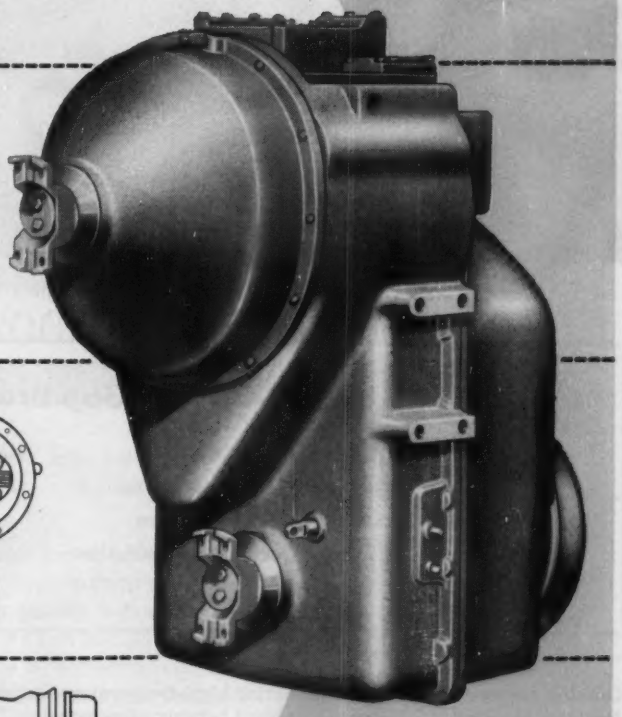
only the HYDRA-DRIVES® BDB

OFFERS ALL THESE MAJOR ADVANTAGES

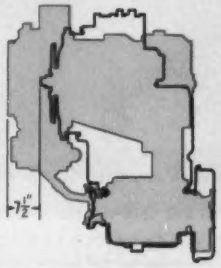
IN FULL-POWER SHIFT TRANSMISSIONS for equipment up to 175 h.p.



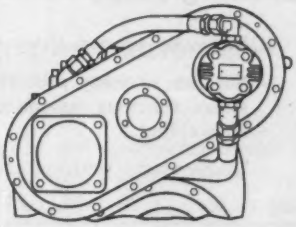
1. **4 speeds forward and reverse.** All power shifted! Provides maximum horsepower to load under all load conditions.



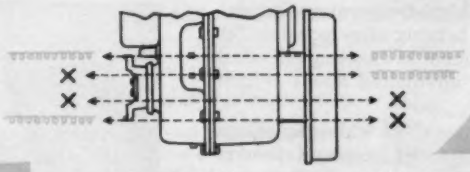
2. **Integral design.** Torque converter, transmission, oil passages, valving and oil sump are in *one* compact housing—7½" shorter than comparable models.



3. **Triple pump drives** – Allow implement and steering booster pumps to be installed close to the oil reservoir. Installation and maintenance costs are reduced. Single pump drive is also available.



4. **Full disconnect** provides four combinations of split drive . . . from torque on both shafts, to both shafts in disconnect.



DESIGNED FOR SPECIALIZED EQUIPMENT

Rockwell-Standard's new model Hydra-Drives Full Power Shift Transmission is designed for specialized equipment, such as front end loaders, fork trucks, scrapers, crane carriers, rubber tire tractors and military vehicles.

The Hydra-Drives BDB offers easier servicing and maintenance. There are fewer moving parts and bearings. The simple, rugged countershaft design and spur gears simplify maintenance.

A larger CBD Transmission is also available for equipment up to 250 H.P.

Another Product of...

ROCKWELL-STANDARD CORPORATION

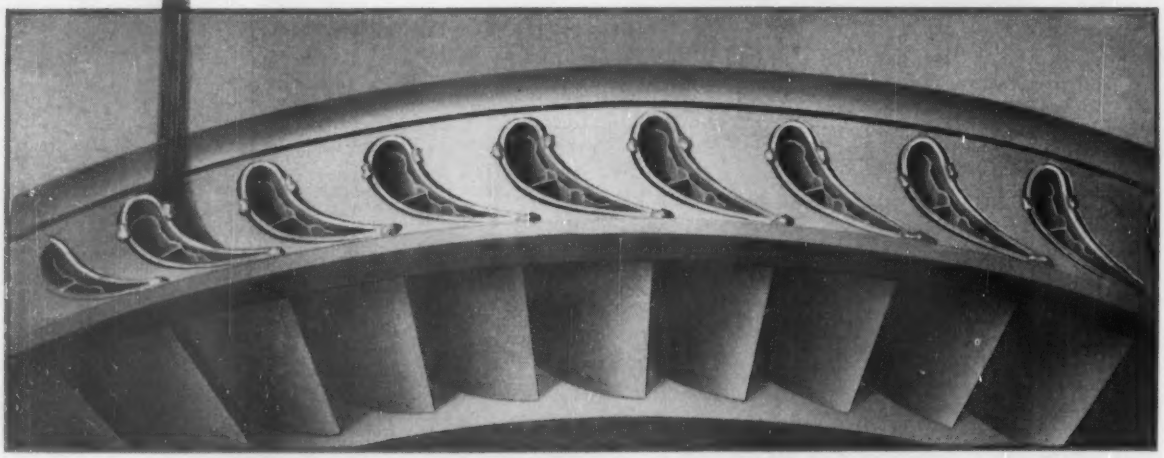
ROCKWELL R STANDARD®

Transmission and Axle Division, Detroit 32, Michigan

Circle 467 on Page 19

Metallurgical Memo from General Electric

G-E Vacuum-Melted Alloys Now Conquer Wide-Gap Brazing Barriers



Wide-gap brazing alloy is applied to turbine nozzle assembly. Vanes are tack-welded in position prior to brazing.

New G-E Wide-Gap Brazing Alloys offer:

- New brazing techniques
- Bridging of joint clearance up to .060 in.
- Faster, more simplified job fabrication
- Extreme cleanliness provided by induction vacuum melting
- Improved erosion characteristics
- Solution to many problems of distortion and stress relieving associated with fabrication by welding
- Lower manufacturing cost

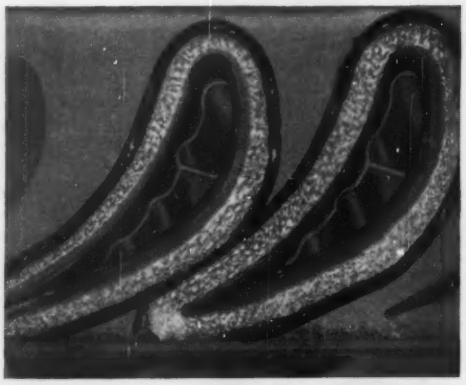
Looking for new methods of fabricating high-temperature metals? Nothing can equal G-E vacuum-melted brazing alloy powders for critical applications. All provide the ultimate in exacting chemical control and extreme cleanliness which air-melted alloys cannot match.

Now this latest G-E brazing "breakthrough" of wide-gap alloys extends the use of brazing to a new, wider scope of joining applications.

Get all the facts about G-E vacuum-melted brazing alloys as a short-cut to lower cost manufacturing methods. Write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Avenue, Detroit 32, Michigan.*

METALLURGICAL PRODUCTS DEPARTMENT

GENERAL ELECTRIC



Insert shows vanes completely brazed in spite of gaps. Stains around perimeter of brazes are from stopoffs.

CARBOLOY® CEMENTED CARBIDES • MAN-MADE DIAMONDS • MAGNETIC MATERIALS • THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS

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CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

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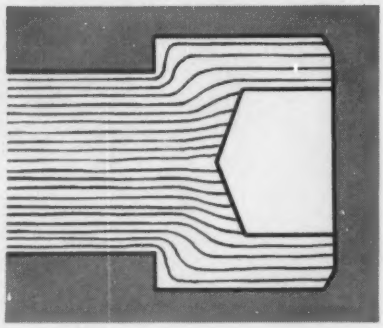
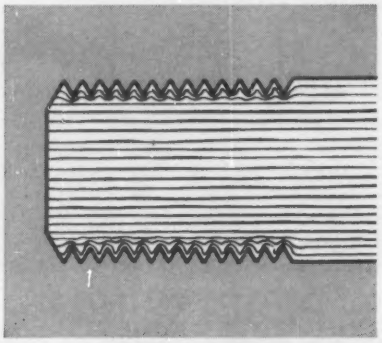
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

How imaginative design produced a better socket head cap screw

Forged heads:
It used to be that all socket head cap screws were *machined* from bar stock, but research revealed that fatigue failures were most likely to occur where the natural lines of strength in the metal were cut. So SPS began forging the heads of UNBRAKO cap screws . . . thus maintaining good flow lines and increasing fatigue strength.



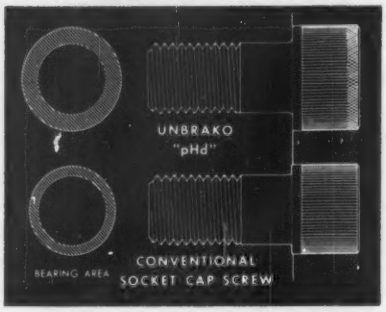


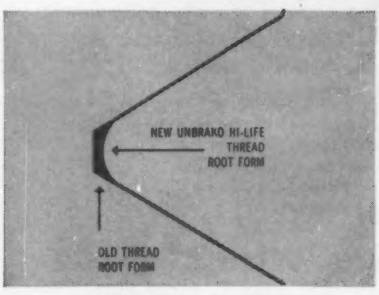
Fully formed threads:
A similar problem in the threads was solved in a similar way. The threads—even more fatigue prone than the head—had always been cut or ground. But now threads were pressed in by precision dies. Once again, maintaining the flow lines of the metal added greatly to the screw's strength.

So fasteners were now precision fabricated throughout. Then the design engineers took over, for despite the strides signaled by forged heads and fully formed threads, there was still much to be done to make screws truly reliable.

pHd* heads:
Research indicated that there simply was not enough load bearing area under the head. What came out of this finding? UNBRAKO pHd cap screw, with a larger head diameter that increased load carrying capacity as much as 2⅓ times, allowing fewer screws per assembly.

* *pHd stands for "proper head design"*





Hi-Life thread:
Then, as you might expect, the design engineers turned their attention to the threads. In the root of the thread were sharp corners where fatigue failure could begin. At the SPS Laboratories for Advanced Research, photoelastic studies made strikingly evident the value of a *smoothly radiused* root over a conventional flat thread root. And so was born the UNBRAKO Hi-Life thread form, which reduces stress to a minimum and distributes the remaining stress evenly.

Now you have at your disposal a socket screw that is stronger in the head, stronger in the thread. The UNBRAKO pHd with Hi-Life threads is indeed the advanced fastener for the '60's. All this—at no additional cost. Standard Pressed Steel Co. INDUSTRIAL FASTENER Division, SPS, Jenkintown 18, Pa.

sps

where reliability replaces probability

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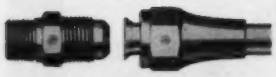
offers one source for all tube fitting needs... a complete line of flared, flareless or pipe...

TUBE FITTINGS of BRASS, CARBON or STAINLESS STEEL

BRASS FITTINGS



S.A.E. 45° FLARE
USED with copper, brass, aluminum, steel and plastic tubing. PRESSURE RATINGS up to 5000 p.s.i. **Sizes: ⅛" to ¾".** Also available in 37° heavy pattern brass. Listed by U.L.; approved by A.G.A. Meets specs of S.A.E. Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping.

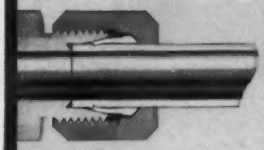
COMPRESSION
USED with copper, brass, aluminum and plastic tubing. PRESSURE RATINGS up to 2000 p.s.i. **Sizes: ⅛" to ¾".** Listed by U.L.; approved by A.G.A. Meets specs of S.A.E. Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping.

SELF-ALIGN®
No flaring, soldering, welding—insert tube and tighten nut. USED with copper, brass, aluminum and plastic tubing. PRESSURE RATINGS up to 2000 p.s.i. **Sizes: ⅛" to ¾".**

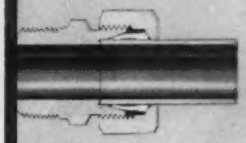
INVERTED FLARE
USED with copper, brass, aluminum, steel, Bundywald and plastic tubing. PRESSURE RATINGS up to 3000 p.s.i. **Sizes: ⅛" to ¾".** Listed by U.L. Meets specs of S.A.E. Hydraulic Tube Fittings and A.S.A. and A.S.M.E. codes for instruments and control piping.

PIPE
USED with brass or steel pipe. PRESSURE RATING: up to 5000 p.s.i. **Sizes: to 2".** Meets specifications of S.A.E. TPHL Fittings Committee.

FORGED STEEL FITTINGS

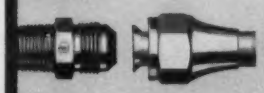


"7000" SERIES ERMETO®
U.L. listed. Meets J.I.C. standards. S.A.E. approved "O" Ring boss design. Dryseal pipe thread. Needs no flaring. Available in either carbon or stainless steel. Carbon steel fittings have "Weathercoat" or cadmium-plate finish. PRESSURE RATINGS: up to 10,000 p.s.i. **Size Ranges—⅛" through 2".**



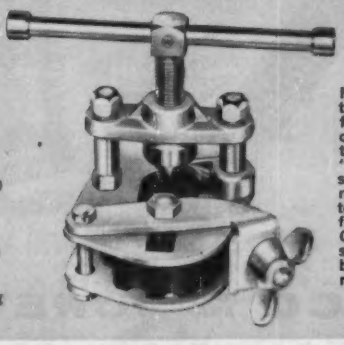
"8000" SERIES ERMETO®
Listed by U.L. for use with hazardous liquids, fuel equipment, refrigeration and gas; meets specs of S.A.E. and J.I.C. hydraulic tube fitting standards. Supplied as standard in cadmium-plate carbon steel and in stainless steel. Requires no flaring. PRESSURE RATINGS: up to 10,000 p.s.i. **Size Range—¼" through 2".**

FLARE-TWIN—(2-pc. or 3-pc.)
37° FLARE STEEL TUBE FITTINGS
Listed by U.L. S.A.E. and J.I.C. approved. Used with J.I.C. and other soft steel tubing; also with copper, aluminum, and fully annealed stainless steel tubing. Meets S.A.E. standards for straight thread boss mounting. PRESSURE RATINGS up to 10,000 p.s.i. **Sizes: ⅛" through 2".**



FLARE-TWIN
Made in 3-piece and 2-piece assemblies. 2-piece type offers price advantage. "Weathercote" or cadmium-plate finish.

FAST! EASY! ACCURATE TUBE WORKING TOOLS



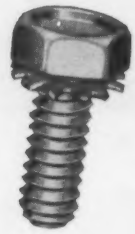
New rotary flaring tool for perfect tube flaring. Fast . . . one piece construction. Easier . . . "Dial - Matic" tube size selection. Accurate...tube stop automatically controls flaring diameter. Compact . . . easy to store. Available with burnishing attachment.

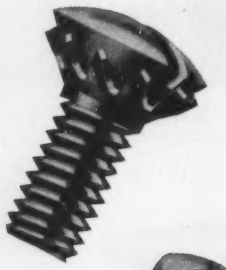
Spring-Type Bender | Mechanical Bender | Tube Cutter | Bar-Type Flaring | Tube Swaging | Automatic Flaring Rotary

THE WEATHERHEAD COMPANY

FORT WAYNE DIVISION • Dept MD-10, 128 West Washington Blvd. Fort Wayne, Indiana

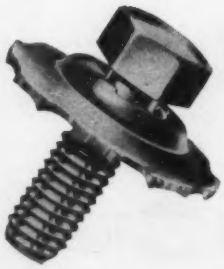
ELCO®





SEMS

These efficient screw-and-lockwasher assemblies are successfully used for cost-saving in thousands of manufacturing plants. Many are made by ELCO — because ELCO has the equipment, and the experienced people, to make them well. Illustrated here are a couple of standards — and a number of "specials", designed and tooled by ELCO to suit unusual and specific requirements. *Buy your standard SEMS from ELCO — let ELCO design your special SEMS.*



SEMS

ELCO TOOL AND SCREW CORPORATION

1119 SAMUELSON ROAD, ROCKFORD, ILLINOIS

Looking for the newest, most complete line of General Purpose Switches?

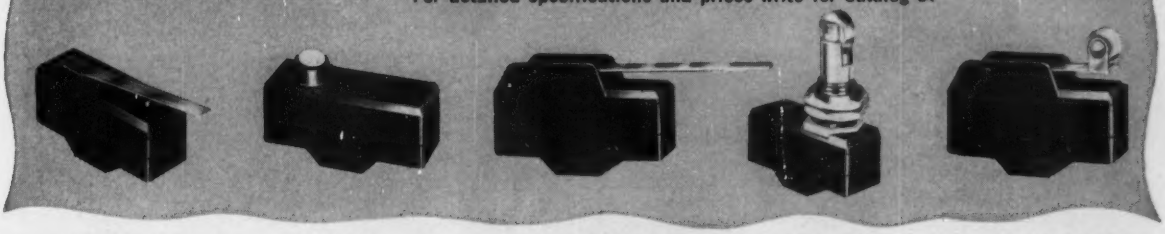
Acro's newly designed model B and F switches will meet your toughest electrical and mechanical requirements

Just check Acro's brand new features!

1. ***NEW!*** Acro's clip-on cover construction, which requires no drilling or pinning, eliminates bakelite dust particles from contaminating the contacts.
2. ***NEW!*** Acro's famous rolling spring principle insures low minimized contact bounce. This gives you high horsepower rating and longer electrical life.
3. ***NEW!*** Up to 21 amp, 2 HP in the F series!
4. ***NEW!*** Moulded-in terminal posts, with blind tap holes, keep out dust and contamination.
5. ***NEW!*** And now Acro offers the most complete line of actuators. Shown are just 10 of the complete series.

model B switches

U.L. Approved 15 AMP 120-240-480 V.A.C. ½ AMP, 120 V.D.C., ¼ AMP, 240 V.D.C.
For detailed specifications and prices write for Catalog B.



BRD2-5L-1S
Leaf Actuator

Operating Characteristics	
Operating force	5 oz. max.
Release force	½ oz. min.
Pretravel	.156 max.
Overtravel	1/32 min.
Movement diff.	.050 max.

BRD2-70-1S
Short Overtravel Plunger

Operating Characteristics	
Operating force	9-13 oz.
Release force	4 oz. min.
Pretravel	.010-.025
Overtravel	1/16 min.
Movement diff.	.003 max.

BRD2-LW8-1S
Overtravel Leaf Actuator (long)

Operating Characteristics	
Operating force	2½ oz. max.
Release force	½ oz. min.
Pretravel	9/32-13/32
Overtravel	.187 min.
Movement diff.	.016-.078

BRD2-24P-1S
Roller Panel Mount

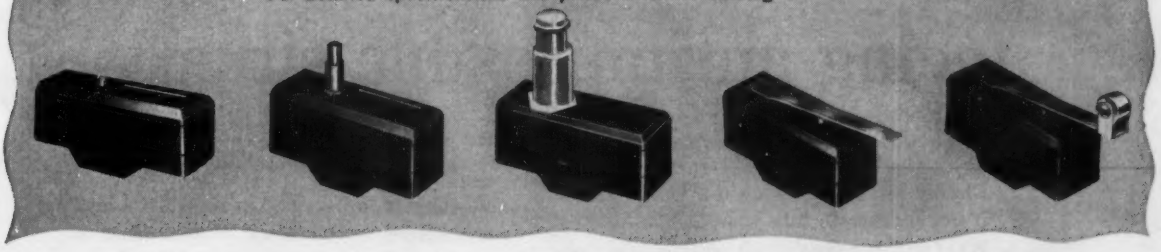
Operating Characteristics	
Operating force	9-13 oz.
Release force	4 oz. min.
Pretravel	.010-.025
Overtravel	.140 min.
Movement diff.	.003 max.

BRD2-LW228-1S
Overtravel Roller Leaf Actuator (short)

Operating Characteristics	
Operating force	6 oz. max.
Release force	1½ oz. min.
Pretravel	.045-.140
Overtravel	.080 min.
Movement diff.	.006-.031

model F

U.L. Approved 21 Amp, 120-240-480 V.A.C., 1 H.P. 120 V.A.C., 2 H.P. 240 V.A.C.
For detailed specifications and prices write for Catalog F



FAD2-1A-1S
Pin Actuator

Operating Characteristics	
Operating force	10-18 oz.
Release force	6 oz. min.
Pretravel	.050 max.
Overtravel	.010 min.
Movement diff.	.0075 max.

FAD2-10-1S
Long Overtravel Plunger

Operating Characteristics	
Operating force	10-18 oz.
Release force	6 oz. min.
Pretravel	.050 max.
Overtravel	1/16 min.
Movement diff.	.0075 max.

FAD2-3P-1S
Large Overtravel Plunger

Operating Characteristics	
Operating force	10-18 oz.
Release force	6 oz. min.
Pretravel	.050 max.
Overtravel	7/32 min.
Movement diff.	.0075 max.

FAD2-5L-1S
Leaf Actuator

Operating Characteristics	
Operating force	9 oz. max.
Release force	1 oz. min.
Pretravel	11/32 max.
Overtravel	1/32 min.
Movement diff.	.065 max.

FAD2-2M-1S
Roller Leaf Actuator

Operating Characteristics	
Operating force	9 oz. max.
Release force	1 oz. min.
Pretravel	11/32 max.
Overtravel	1/32 min.
Movement diff.	.065 max.

for detailed specifications and prices write for catalogs "B" and "F".

Free engineering service. Our engineers will be happy to pit their professional experience against your tough switching problem. Just tell us what it is . . . we'll recommend ways to solve it. No obligation, of course.

RELAYS ACRO SWITCHES

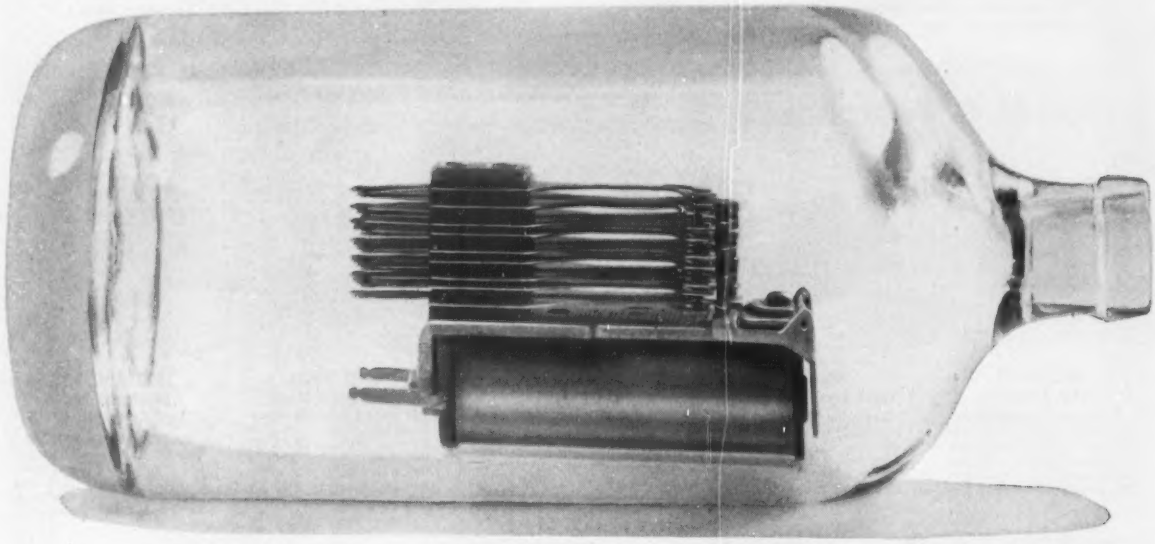
"OUR 21st YEAR"

ACRO DIVISION Robertshaw

MR. CONTROLS

COLUMBUS 16, OHIO

AE



TO THE ENGINEER

facing an impossible situation

If you have a "hopeless problem" in automatic control, chances are that Automatic Electric can help you solve it in less time than it would normally take you.

What with our specialized experience in cooking up highly educated circuits and components for dial exchanges, we've earned a reputation for making ideas *work* automatically.

As an example: the AE Class B premium-quality telephone-type relay (illustrated) provides hundreds of millions of operations with unfailing contact reliability, and seldom needs maintenance. For this reason alone, it is probably the most inexpensive relay you can use where infallibility is essential.

As a support to your design skill, AE relays and stepping switches are custom-made to your precise engineering specifications. They're also available wired and assembled into complete control packages—a job we can handle for you at low unit cost.

For more information, write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1702-E on *Relays for Industry.*

AUTOMATIC ELECTRIC

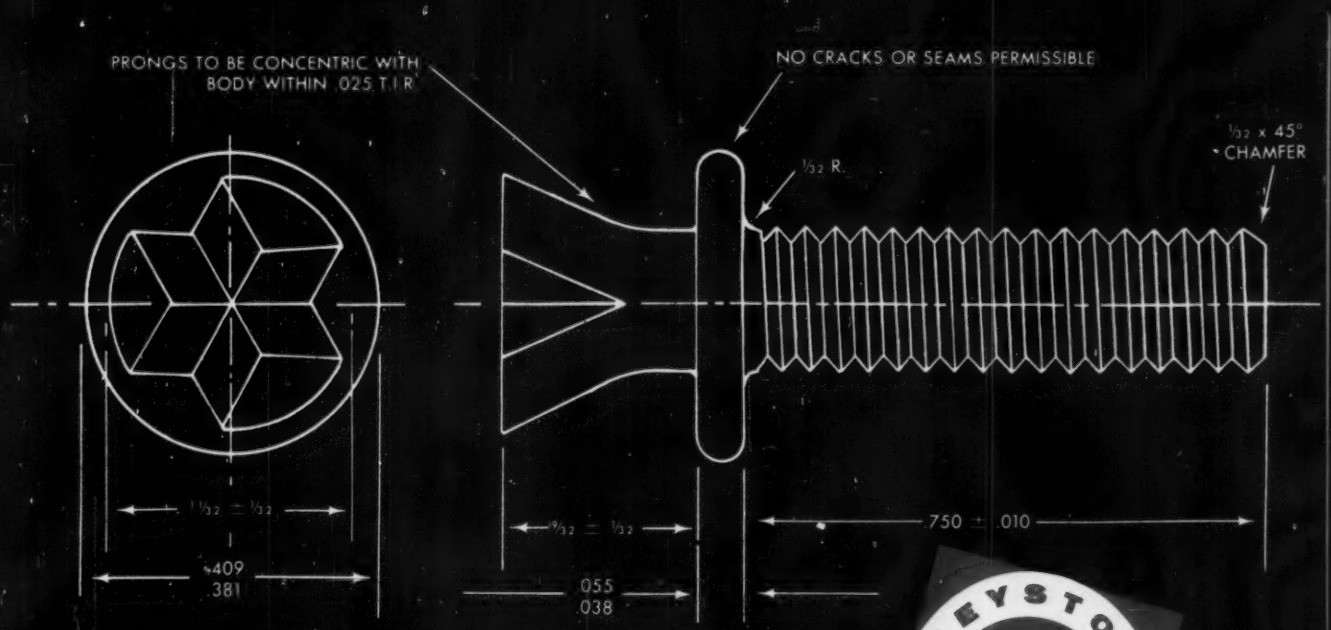
Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

Circle 474 on Page 19

Circle 475 on Page 19→



NOTE
1 — USE SPECIAL PRONG AND COLLAR GAUGE #1053
2 — CLASS 2A THREAD AFTER PLATING
MAJOR DIA. — .1891 — .1831
PITCH DIA. — .1688 — .1658

MATERIAL
KEYSTONE XL WIRE
C-1018 — .165 DIA.

10-32 x 3/4
TERMINAL BLOCK STUD

PIONEER SCREW & NUT CO.
MELROSE PARK, ILLINOIS

DIFFICULT — BUT SOLVED
BY PIONEER SCREW & NUT CO.
with KEYSTONE XL WIRE

Faced with a difficult heading problem, Pioneer Screw & Nut Co., Melrose Park, Illinois, uses Keystone XL .165" Cold Heading Wire to upset, in a double blow, the terminal block stud illustrated here. This stud with its three prongs embedded into a plastic strip becomes an electrical terminal stud for such major heavy appliances as stoves, refrigerators, dryers, washers.

Specials from Pioneer Screw & Nut Co. require Keystone XL Wire when flowability for extreme shapes is required, such as this terminal block stud.

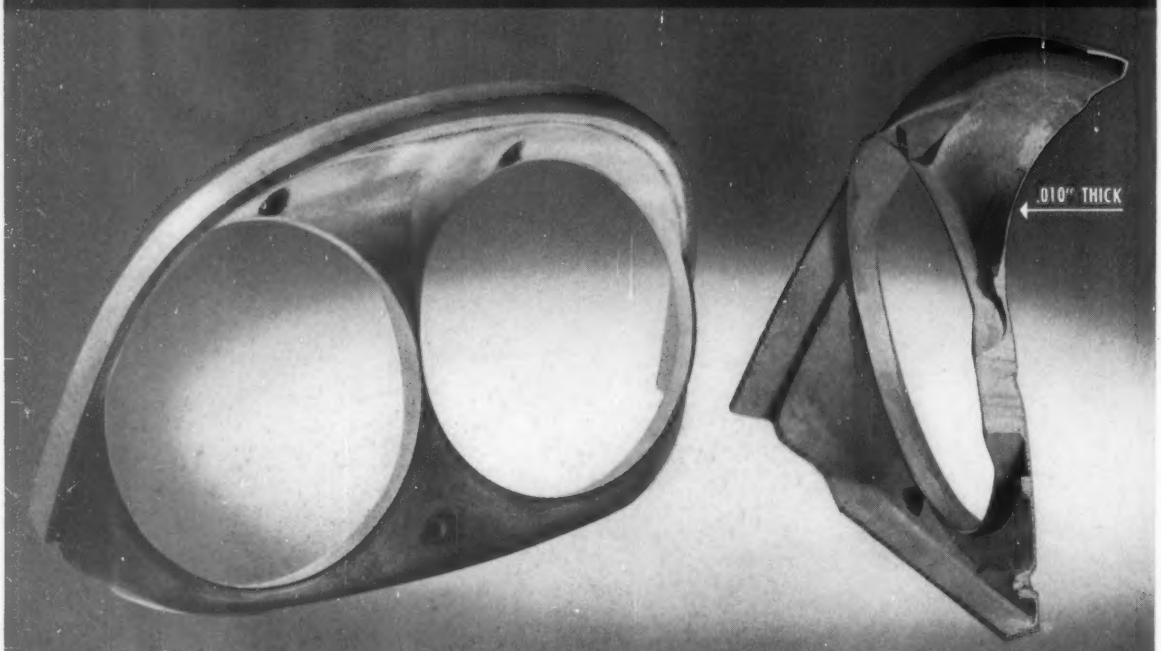
Says Robert A. Hirsch, President, "Pioneer's consistent high torque and quality requirements for our special screws are the reasons why we specify Keystone Wire. The end products result in better screws supplied to our customers."

Should you have wire forming problems, send us your blue prints and specifications. Our metallurgists will be pleased to analyze your wire requirements. Or call your nearest Keystone Wire Specialist; he is highly qualified to help you.

Keystone Steel & Wire Company, Peoria, Illinois

KEYSTONE
WIRE FOR INDUSTRY

IT'S LIGHTER THAN YOU THINK!



SMOOTH-FLOWING DESIGN . . . BRIGHT, LASTING FINISH
RIGID . . . DURABLE . . . ECONOMICAL

. . . WHEN DIE CAST with ZAMAK

Airfoil sculptured styling of today's automobiles demands parts designed to complement flowing body and fender lines.

ONLY ZINC DIE CASTING ALLOYS can produce the intricate shapes and smooth, compound-curve surfaces—as in this headlight door — with the necessary thin-wall sections, strength, rigidity and production economy.

Improved techniques in chromium plating on Zamak die cast parts provide a more permanent bright finish with greater resistance to corrosion than ever before.

The weight-saving advantages of ZINC die castings, with built-in qualities of durability and economy, point up the important reasons why Zamak has become the leading material for the production of die cast parts in today's automobiles.

HORSE HEAD® SPECIAL ZINC AND HORSE HEAD ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

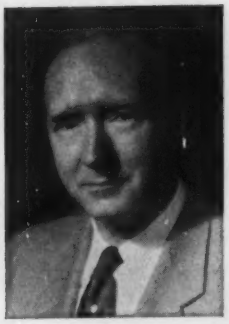
DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

160 Front Street • New York 38, N. Y.

HORSE HEAD PRODUCTS ®

MACHINE DESIGN

October 27, 1960



Wanted: Experience

WANT-ADS for design engineers almost invariably stress experience as a primary qualification. Yet the experience of one man, or any group of men comprising an engineering organization, is meager alongside the vast storehouse of scientific and engineering know-how available in published works.

Most engineering problems break down into elements which recur—which have been solved before and often are recorded in the literature. A creative engineer, however, is hired to develop new ideas and designs, not to reinvent old ones.

It is therefore part of his responsibility to review what others have done, before he spends time and resources on possible duplication of others' efforts.

Wise management recognizes this obvious approach to cost saving in engineering development. As Harold Sharp points out elsewhere in this issue, a carefully planned department library can be a powerful aid in more effective use of development dollars.

But engineers need to guard against two extreme attitudes toward the use of books and periodicals. One type tends to scorn such aids, perhaps afraid that reliance on them will reflect on his own competence or will be judged a waste of time. The other tends to lean so heavily on published information that his own creativity is stifled.

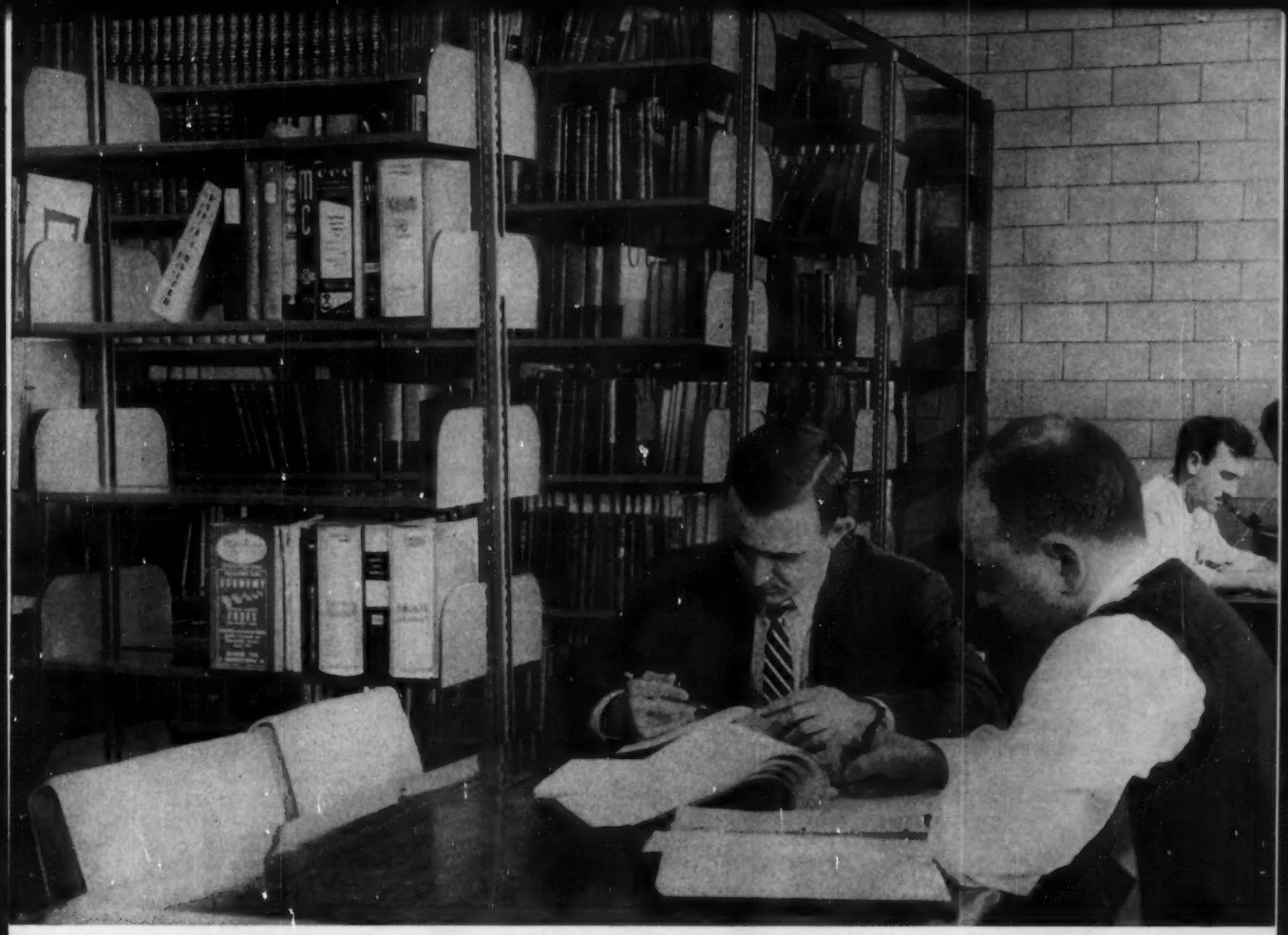
The truly experienced engineer, confident in his mastery of his profession, knows when to rely on his own resources and when to capitalize on the experience of others. Creative engineering is a judicious combination of both.

Colin Carmichael

EDITOR

ENGINEERING LIBRARY COSTS

As in many business ventures, the initial period of a company engineering library is the most expensive—the least profitable. However, this kind of library can pay off handsomely, particularly in literature searches. This article shows how much it costs to start a library, and what it takes to keep it going.



HAROLD S. SHARP
Technical Librarian
AC Spark Plug Div.
General Motors Corp.
Milwaukee, Wis.

MONEY invested in a library gives much better returns than mining stocks." This observation, made over half a century ago by Sir William Osler, is even more true today, particularly as it pertains to libraries organized and operated by companies. A company library can save the time of engineers and executives by providing needed information quickly and accurately.

Probably the most important service a company library can furnish is literature search prior to laboratory research, thereby avoiding repetition of laboratory work. Another highly important function is to furnish the kinds of books and technical journals which enable engineers and other employees to increase their learning and to keep abreast of developments in their fields.

In 1953 there were over 2500 company libraries in the United States, and since that date the number has increased to over 4000. Evidently, many industrial firms realize the value of establishing and maintaining their own libraries.

Initial Facilities

A company library is not inexpensive. At the outset, a company must realize that its investment must be adequate to be profitable. Basic library tools—indexing services, and technical periodicals—are expensive but essential.

In addition to the basic library tools, such items as staff, floor area, furniture, and fixtures must be considered. Since these things are costly, they must be selected carefully. Many technical considerations are involved. The company which considers establishing a library should engage a library consultant. The Special Libraries Association, 31 E. 10th St., New York 3, N. Y., can provide such a consultant.

ENGINEERING LIBRARY COSTS (Continued)

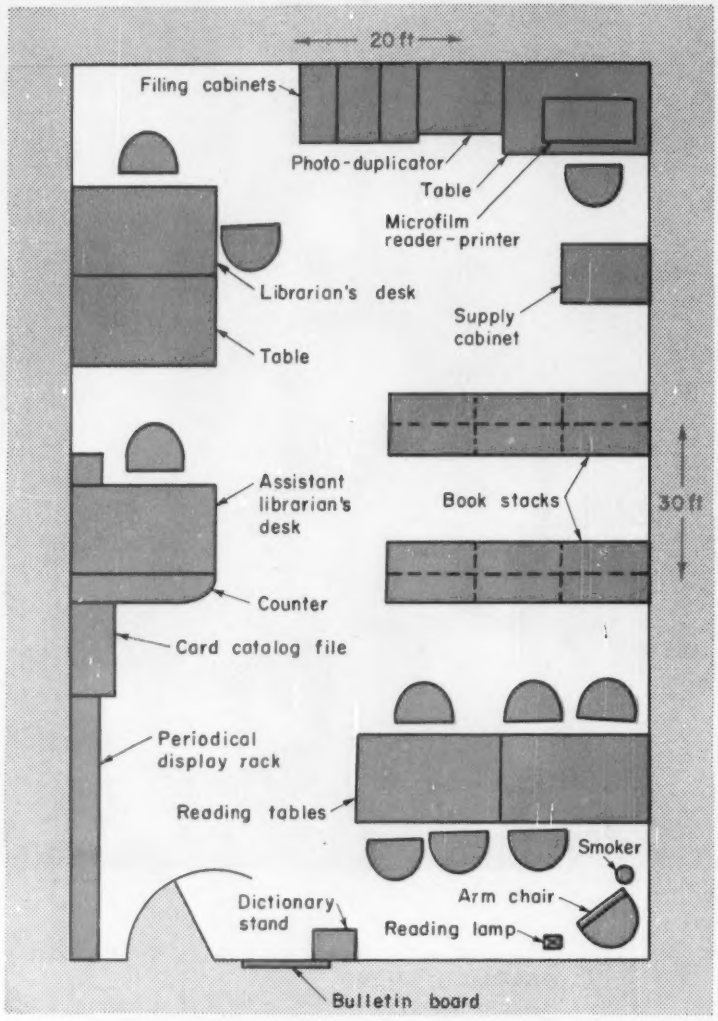


Fig. 1—Minimum floor plan for a company library.

This expert, as a practicing special librarian, will give one day's service without charge. Further services are on a per diem basis.

Operating Personnel

The technical librarian is a trained specialist. In addition to a Bachelor's degree, he often holds a Master's degree in Library Science, and he has served an apprenticeship as assistant librarian in a company library. It is false economy to have an engineer plan and establish a company library. However willing, he does not have the necessary technical knowledge or background of library science to do the job.

Today, the demand for librarians far exceeds the supply, so finding a competent librarian is not easy. Recruiting leads and sources are: 1. The Special Libraries Association, which maintains a placement service. 2. University graduate library schools, which can refer new graduates. 3. Public librarians, who may be able to furnish information. 4. Advertising in library trade publications.

Budget Items

To prepare a budget, the librarian must first determine what library services his company requires. A company engaged in a heavy program of research and development needs a relatively large expenditure for library information services. One study, made by the National Association of Manufacturers, to determine the relationship of total sales to the amount spent for research by various business concerns, reports an average of 2 per cent of sales spent for research. This study further shows that from 1 to 1½ per cent of this 2 per cent was spent for library services.

Another study, reported in *Special Libraries* for April, 1957, showed that library dollars per engineer varied from a low of $3 to a high of $152, with an average of $40.50. In 1958, the author made a study, covering electronics libraries only, which showed a low of $6, a high of $50, and a median of $28. These figures do not include the salaries of the library staff. If they did, there would be little

variance between one library and another.

Salaries: The major item on the budget is the salaries of the staff. A 1948 study, reported in *Special Libraries*, found that from 60 to 90 per cent of the average library budget is allocated for salaries. Salaries for the library staff should range downward from that paid the chief librarian. Job evaluation procedures should be used.

Books: There are two types: Reference and text. Reference books give short, succinct answers to specific questions. Examples are dictionaries, tables of logarithms and other numerical data, and handbooks. Text books, on the other hand, contain comparatively lengthy discussions of particular subjects.

As a general thing, reference books do not circulate, and may be used for a number of years before they become obsolete. Text books, tend to become obsolete fairly quickly. Since they must be studied, patrons may borrow them.

Initial expenditure for books will be greater than in succeeding periods because of the difference in obsolescence rates between reference and text types. Buy books as the need for them becomes apparent, but proceed slowly. Scientific books are expensive. Today, 100 such books will cost over $700.

Periodicals: Whereas books are subject to obsolescence, periodicals contain up-to-date reports on happenings within the fields they cover. For this reason it is necessary to receive a number of these journals. It is also advisable to maintain copies of certain periodicals in bound form as part of the reference collection. Consequently, the cost of binding must be considered in the library budget. Where advisable, back copies of specific periodicals should be obtained and bound. When these are not available, or are available only at great cost, microfilm may be considered.

Since periodicals grow about 7 in. of shelf space per year per title, the use of microfilm should be given serious consideration. Microfilm takes up far less space than original documents. If used in conjunction with a microfilm reader-printer, full-sized reproductions may be made quickly. Pages of bound periodicals can be photocopied by machines now on the market. Back issues of most worthwhile periodicals can be obtained on microfilm from such sources as University Microfilms, Ann Arbor, Mich.

Reference Services: Due to the volume of technical information being published today, it is not possible for any one library to have all required information available on its shelves. However, a librarian can use commercial reference services to track down information outside his own library. *Engineering Index*, published at 29 W. 39th St., New York 18, N. Y., abstracts some 1400 technical periodicals, reports, and other sources from all over the world, and issues 3 by 5-in. cards on which these abstracts appear. Abstracts are divided into subject categories which are available by subscription. All cards published throughout each calendar year are available in book form, published annually. Translations of foreign-language articles, if abstracted, may also be obtained from the publisher of the *Index* for a fee.

Other indexing services include the *Applied Science and Technology Index* and the *Business Periodicals Index*, both published by the H. W. Wilson Co., 972 University Ave., New York 52, N. Y. These indexes are issued in book form on a monthly basis, and are cumulated periodically. The *Cumulative Book Index*, also published by Wilson, contains information concerning newly published books, whereas the other indexes mentioned pertain to periodical articles.

Society Memberships: The cost of memberships in technical societies might be charged to the library budget if the societies publish proceedings which are valuable to the company. Some concerns feel that employees who wish to progress professionally should pay for their own memberships in professional societies. In any event, publications of such societies should, where possible, be placed in the library collection.

Hardware: The cost of furniture and fixtures will depend on the size of the library. A *minimum* layout, Fig. 1, would cost at least $4000, using standard office desks, table, cabinets, and other equipment. This amount does not include the cost of the floor space.

Location and Space

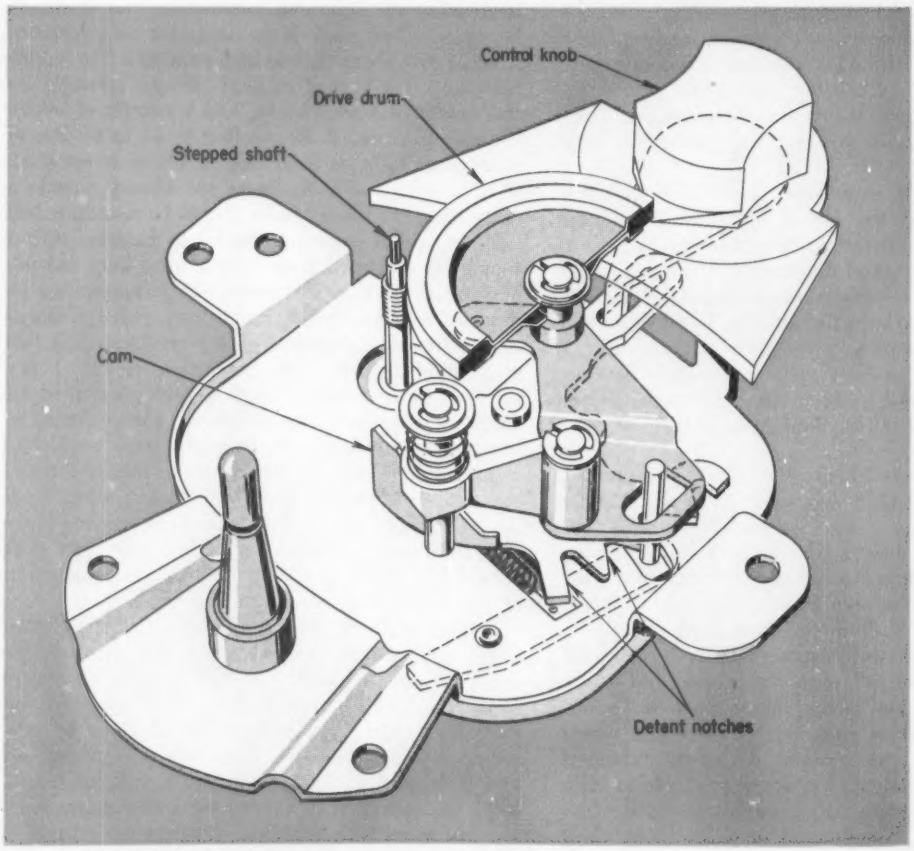
The ideal place for the library is a separate room which is convenient to those who use it. It should have adequate light and ventilation, and it should be quiet. Floor load is an essential consideration. A book stack seven shelves high requires a floor which will support a load of at least 140 psf, allowing for the weight of stacks, books, and a margin of safety. Illumination needed for reading is 40 to 60 ft-c of shadowless light at desk height. Quiet is essential. If it is not possible to locate the library outside a noisy area, the library room should be soundproofed.

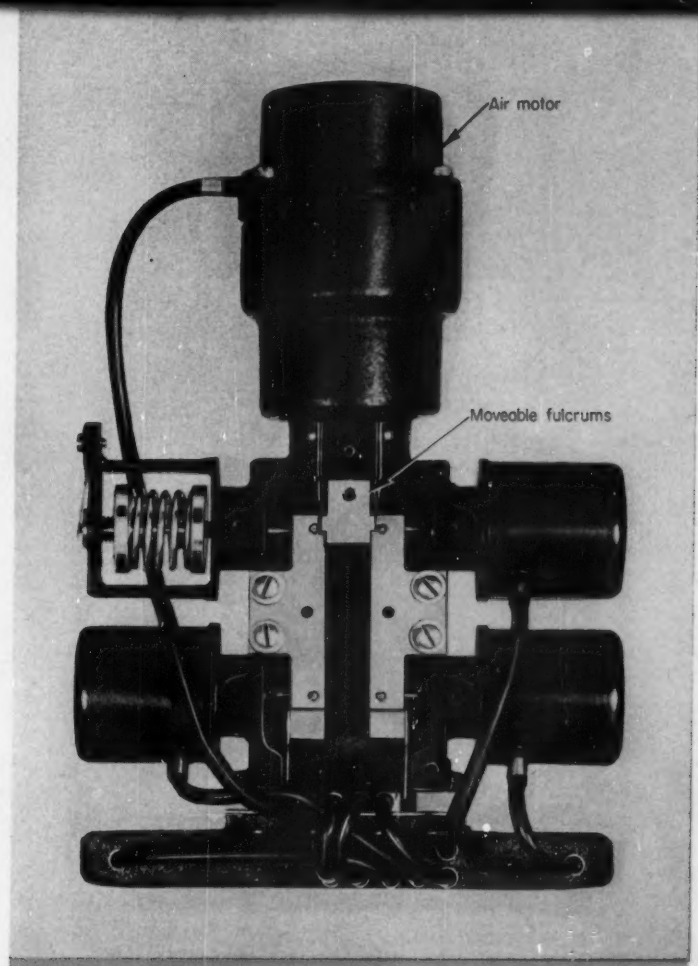
With careful planning, much can be done with a comparatively small floor area. The library should, however, have sufficient space if it is to perform its mission properly. Requirements vary with individual organizations but, generally, any area less than 600 sq ft is inadequate. The floor plan in Fig. 1 has certain features which should be incorporated in all company libraries. It is necessary, for example, to separate the reading area from the work area. Patrons should be able to talk with the librarian without disturbing persons using the reading area. Book stacks and periodical racks should be conveniently near the reading tables, and the librarian's desk should be located to permit unobtrusive observation of the entrance door and reading area.

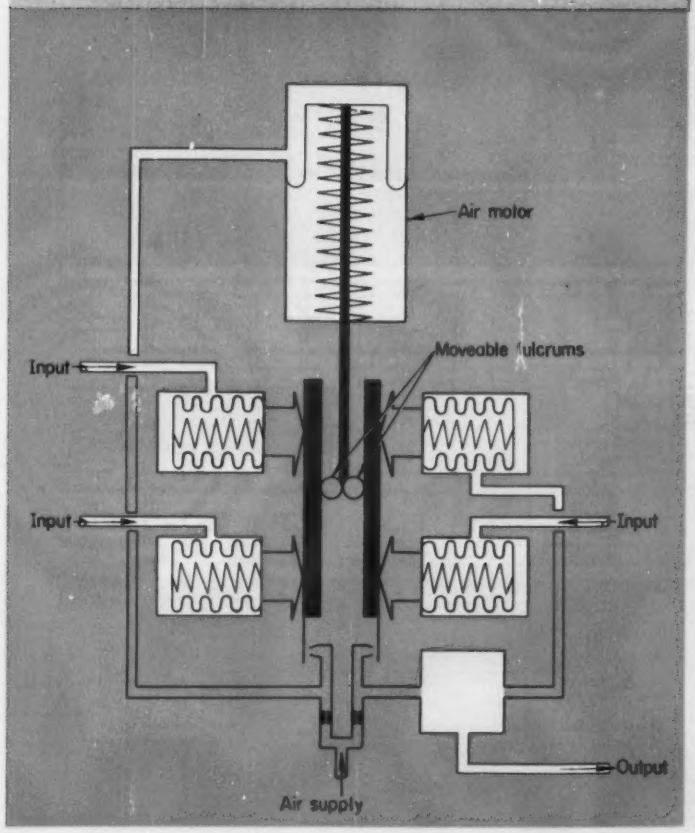
Studies made by the Special Libraries Association show that company libraries expand by doubling every 12 to 15 years. For this reason, allowance should be made for expansion, either by providing more floor than the minimum 600 sq ft, or by providing storage space for back issues of periodicals and little-used books. The librarian will, of course, weed the collection of extraneous and obsolete matter, but even with weeding, libraries do expand. ●

scanning the field for *ideas*

Hopping drive drum provides correct ratios to drive a phonograph table at desired operating speed. A linkage and stepped-cam arrangement positions the friction drive drum against the stepped motor shaft to transmit power to the inner surface of the turntable flange. "Cams" between detent notches pull drum from motor shaft when speed is changed. Principle employed in drive developed by General Industries Co., Elyria, Ohio.

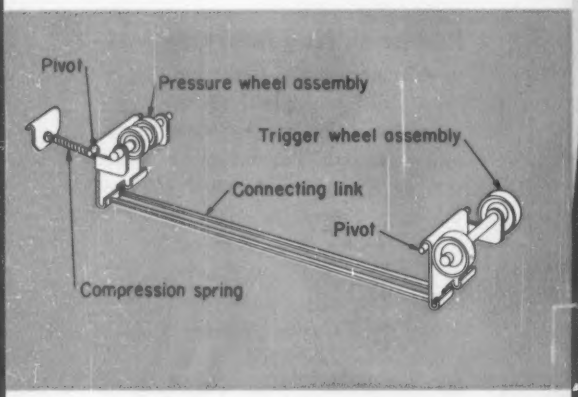


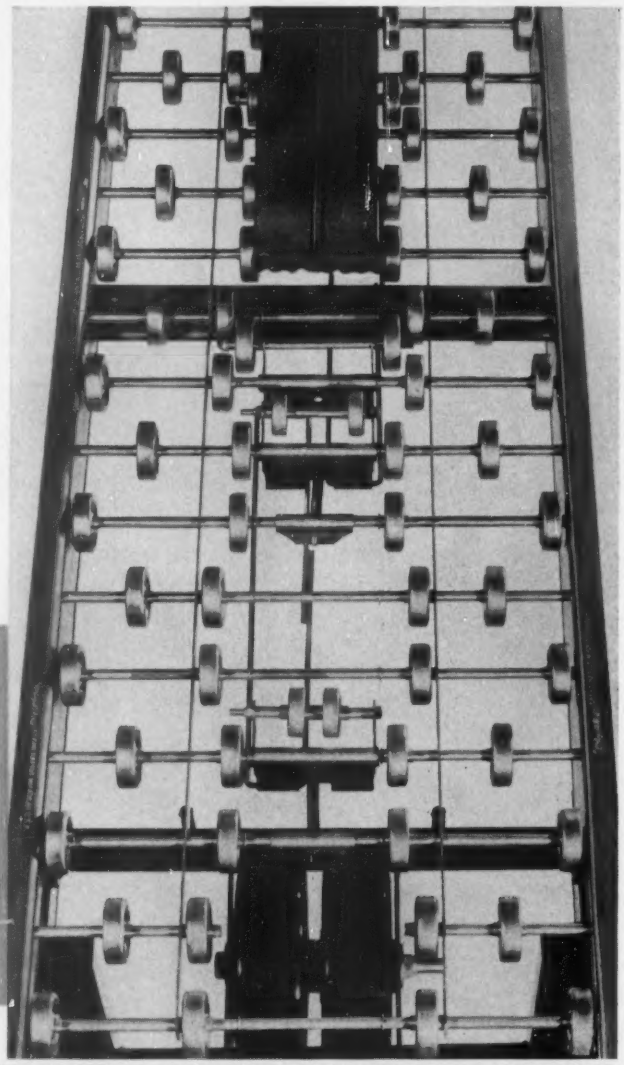


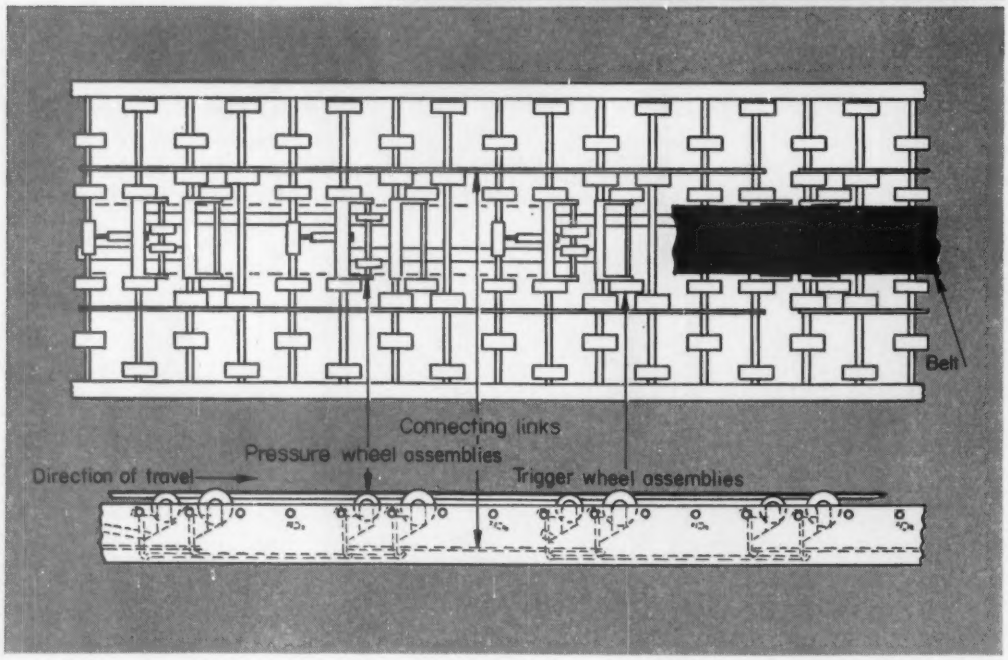


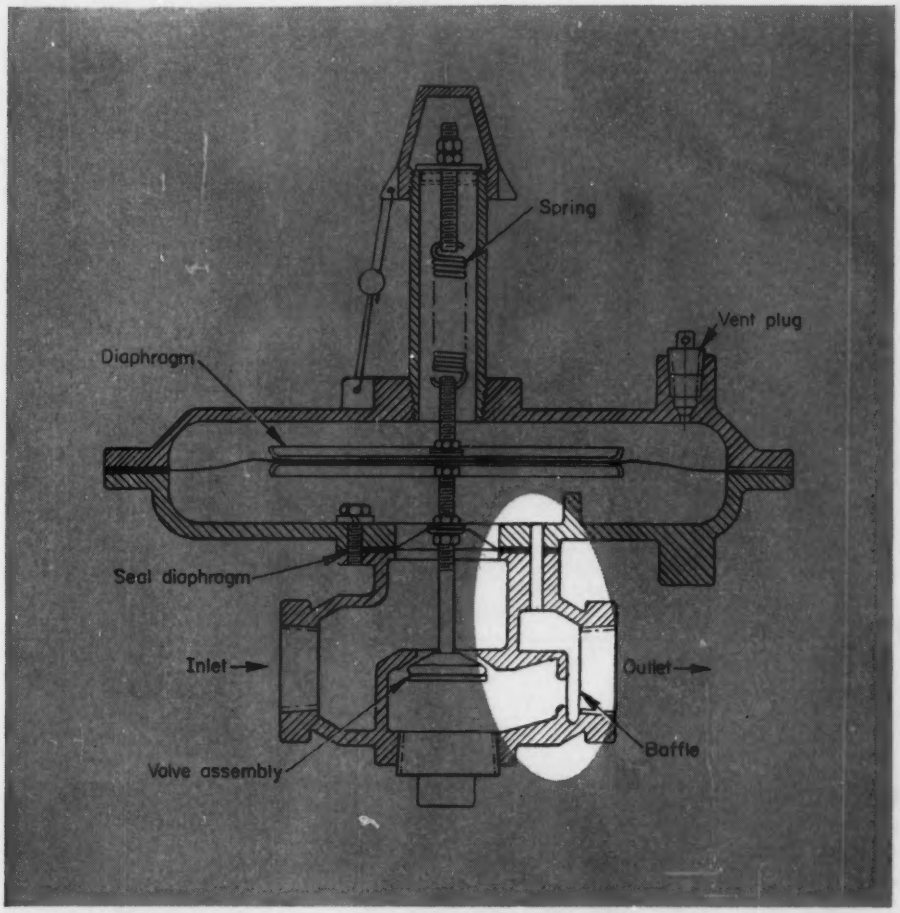
Power-shifted fulcrums permit pneumatic force balance to multiply, divide, square, extract square roots, and set ratios. Two beams rotate on the common movable fulcrum. Forces representing input signals are impressed upon the beams by pressure cells. Through two feedback loops, the fulcrum position is changed and the forces applied by the pressure cells are altered until the beams are parallel and balanced. When this condition is satisfied, the two forces impressed upon each beam are related by a simple equation of moments. Principle employed in pneumatic computer developed by Fischer and Porter Co., Warminster, Pa.

Spring-loaded trigger wheels, depressed by a stopped package on a conveyor, lower belt pressure wheels from following package. Each package thus stops the following one to prevent build up of line pressure. When first package is released, the trigger-wheel and drive-wheel linkage operates in a reverse sequence, to start packages one at a time. Principle employed in conveyor developed by Rapids-Standard Co., Grand Rapids, Mich.



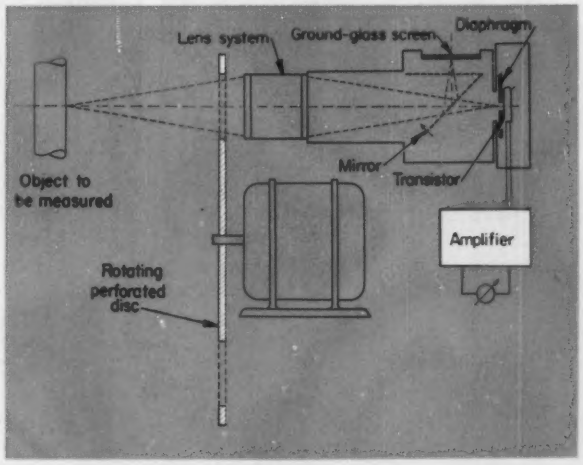


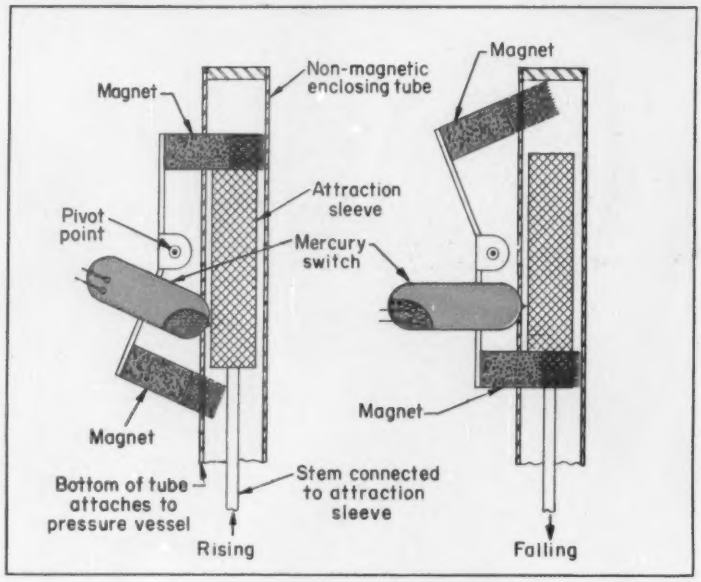




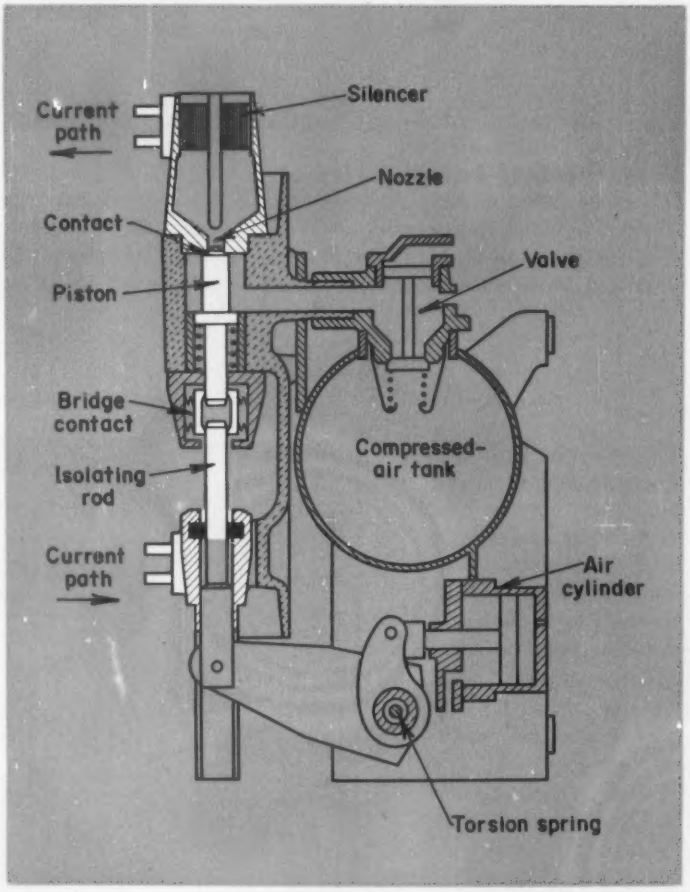
Venturi-effect baffle produces additional operating force in a pressure-regulating valve. The vacuum produced supplements the normal suction to provide additional loading on the diaphragm in opposition to the spring. Thus, flow remains constant regardless of outlet pressure. Principle employed in pressure regulator developed by Bryant Industrial Products Corp., Cleveland.

Chopper-amplifier combination in a pyrometer ignores random fluctuations of light source. The narrow-bandwidth amplifier is sensitive only to the interruption frequency produced by the rotating perforated disc. Principle employed in optical pyrometer developed by NV Philips' Gloeilampenfabrieken, Eindhoven, Holland.





Magnetic toggle switch responds to significant change in liquid level but ignores minor variations which would actuate direct-connected float switch. Principle employed in level-sensing switch developed by Magnetrol Inc., Chicago.



Quench blast actuates opens a circuit-breaker contact, in addition to snuffing out arc. Piston movement also triggers a spring-loaded isolating rod which permanently opens the circuit. An air cylinder closes the circuit breaker and preloads the torsion spring. Principle employed in a circuit breaker developed by Allgemeine Elektricitaets-Gesellschaft, Berlin, Germany.

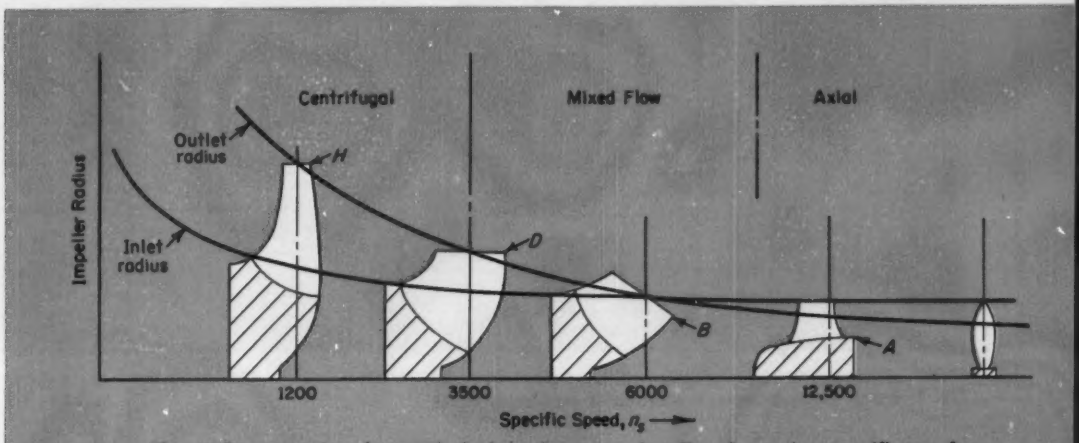


Fig. 1—Representative shapes of single-suction pump impellers for various specific speeds.

How to use

SPECIFIC SPEED

as an aid in centrifugal, mixed-flow, and axial-pump selection

Specific speed is the rotational speed at which a theoretical impeller will deliver 1 gpm at 1 ft total dynamic head. All impellers having a homologous or identical shape, regardless of size, will have the same specific speed. The performance characteristics of any impeller can be applied to any other identically shaped impeller by use of the specific-speed formula.

F. H. LINLEY
Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

HYDRAULIC relationships between sizes and types of centrifugal and other rotodynamic pumps are given by the specific speed. This index provides a basis for the accurate determination of the performance of full-size prototype pumps from model test data. It also provides an excellent means for correlating and cataloging engineering data.

In pump application, specific speed is a valuable reference number. Assuming proper design, hydraulic performance characteristics affecting pump

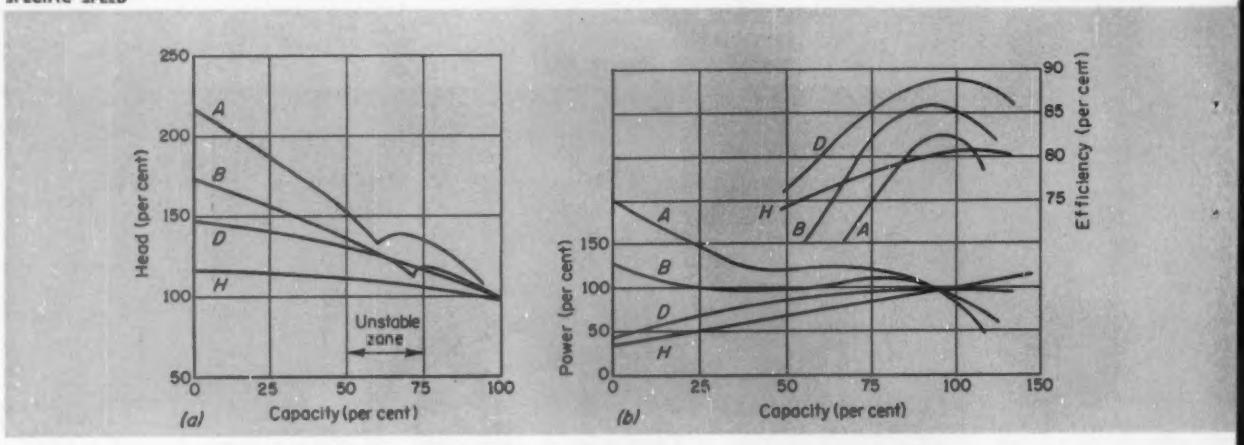


Fig. 2—Pump performance as a function of capacity.

applications fall into general patterns that can be indexed to specific speed. Fig. 1 through 8 show relative performance characteristics which affect pump selection. The curves are typical examples only. Final recommendations must be based on the design data for the specific pump selected.

Specific speed for single-suction pumps is*

$$n_s = \frac{n\sqrt{Q}}{H^{3/4}}$$

Fig. 1 through 8 can be applied to double-suction pumps by diving the double-suction impeller capacity by two, to obtain the equivalent single-suction impeller.

Impeller Shapes: Fig. 1 shows representative shapes of single-suction pump impellers for various specific speeds. It indicates the ranges of specific speeds for impellers commonly designated as centrifugal, mixed-flow, and axial. Although impellers with specific speeds below 1200 and above 12,500 can be used, the range shown is the one most commonly used on large fixed-vane pumping equipment. The shapes in Fig. 1 show why double-suction impellers are usually applied only in the centrifugal or low specific-speed mixed-flow range.

Performance vs Capacity: Fig. 2*a* shows the general shapes of the head-capacity curves of the fixed-vane impeller types in Fig. 1. Centrifugal pumps with low specific speeds have relatively flat head-capacity curves that rise gently toward shut-off. In some cases, head-capacity curves of the low specific-speed pumps tend to droop slightly near the shut-off point. Mixed-flow pumps with medium specific speeds have a more pronounced rise in the head-capacity curve to shut-off. Unstable operation may occur between 50 and 70 per cent of the best efficiency flow.

Head-capacity curves of axial-flow pumps with high specific speeds generally rise to a high shut-off head. They usually have unstable operation at 50 per cent to 70 per cent of the best point flow. Degree of instability and width of the unstable operating zone varies among designs. However, operation at 50 per cent to 70 per cent of rated capacity should be avoided on higher specific speed pumps. In very large pumps, where suction head is an important factor, this zone should be avoided for all specific speeds.

As shown in Fig. 2*b*, the efficiency curves of low specific-speed pumps are relatively flat, indicating that this type is flexible for varying capacities. On higher specific-speed pumps, the efficiency curve tends to break more sharply on either side of the point of best efficiency. This fact tends to limit the application of these pumps, from the efficiency standpoint, to a relatively narrow range of capacity.

The power curves, Fig. 2*b*, for low specific-speed pumps rise steadily from shut-off to the maximum-capacity break-off point. Therefore, an adequately powered driver should be selected to prevent overloading if the total dynamic head is permitted to drop below the rated point. As specific speed increases, the tendency to overload the driver on reduced heads is decreased, but the power and thrust at shut-off are usually well in excess of rated-point values. On high specific-speed pumps, low-flow operation must be avoided, or a driver must be selected that can adequately meet the power and thrust requirements.

Head per Stage: Fig. 3 shows the usual head per

*W. W. Weitmer—"Evolution of Centrifugal Pump Type from a Specific Speed Standpoint," Chicago Section, ASME, Jan. 7, 1957.

Nomenclature

H = Total dynamic head, ft of water per stage
h_{sv} = Net positive suction head, ft of water
n = Rotational speed, rpm
n_s = Specific speed for single-suction impeller
Q = Capacity, gpm
σ = Coefficient

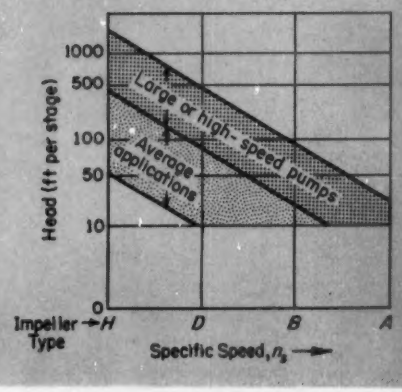


Fig. 3 — Head per stage for various specific speeds.

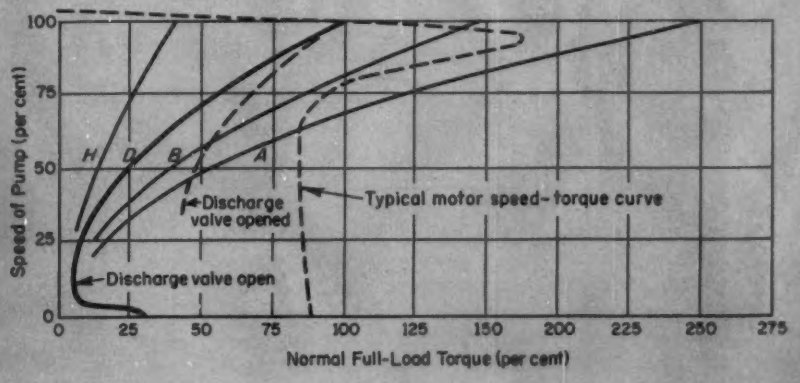


Fig. 4—Pump starting torque (with discharge valve closed) as a function of impeller type.

stage for various specific speeds. Although Fig. 2*a* shows performance-curve patterns in terms of head and capacity, Fig. 3 demonstrates that the 100 per cent, or rated head condition, drops sharply as specific speed increases. For a given head and capacity, the higher the specific speed, the smaller the pump. Also, the higher rotary speeds permit a driver of smaller physical size. This, in addition to possible space savings because of the usual vertical mounting of high specific-speed pumps, often result in lower initial costs. However, head limit per stage for various specific speeds, as indicated on Fig. 3, should be given serious consideration.

Starting Torque: Pump starting requirements also may be correlated with specific speed. Fig. 4 shows speed-torque curves based on starting against a closed pump-discharge valve for the impeller types shown in Fig. 1. The heavy curve indicates the speed-torque relationship for all specific-speed pumps with the head valve open. This curve also approximates the closed discharge-valve curve for a 3500 N_s pump.

As a general rule, pump-discharge valves should be opened before a pump comes to full speed. Time of discharge-valve opening is important on high specific-speed pumps. Incorrect timing will cause excessive starting torque which will prevent the unit from coming up to operating speed within the motor starting-time limit. The discharge valve should be opened before the pump reaches the speed designated by the dashed line in Fig. 4. The approximate speed-torque curve of a large motor is also shown. The area between the two curves represents the torque available to accelerate the pump to operating speed.

Regardless of the starting problem, no pump should run for any time against a closed discharge valve. If flow is excessively restricted, the energy imparted to the fluid will lead to flashing and other thermal problems. Also, extensive operation at restricted flow could lead to shaft fatigue failures in pumps with a single-volute casing.

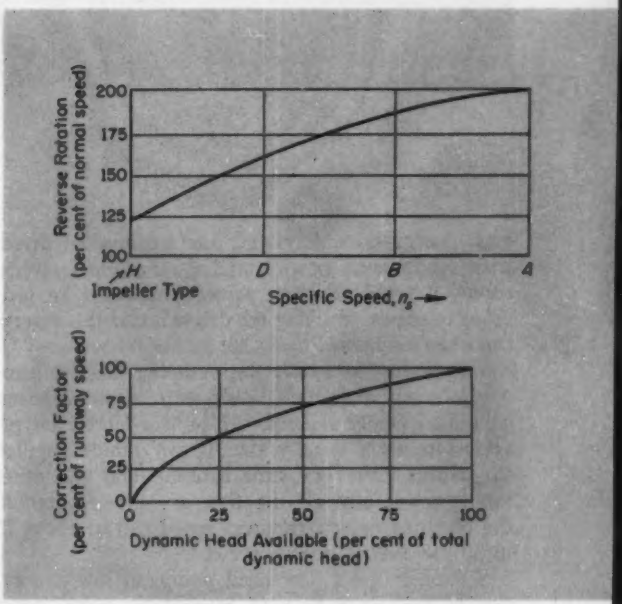


Fig. 5—Reverse rotation runaway speeds that will be developed if total dynamic head is available for reverse rotation, Fig. 5*a*. If less than total dynamic head is available, Fig. 5*b* gives the correction factor to be applied to the value determined in Fig. 5*a*.

Reverse Operation: When reverse-flow conditions are encountered, a pump operates as a turbine. Fig. 5*a* shows the maximum expected reverse-rotation runaway speeds at rated pump head, plotted against specific speed. Reverse-rotation problems are most acute in systems involving high energy storage such as boilers, and large-volume tanks or reservoirs. In such systems, the heads available for reverse flow approach the full total dynamic head of the pump minus twice the normal pipe-friction losses. The reverse runaway speeds in such cases can approach 90 to 95 per cent of the values shown in Fig. 5*a*. In any

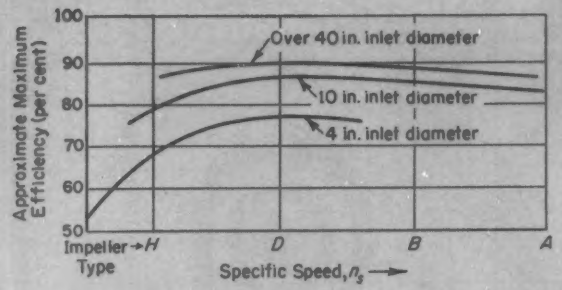


Fig. 6 — Approximate maximum efficiency for various specific speeds.

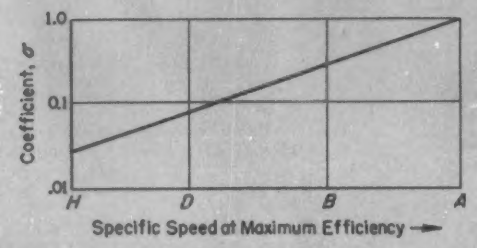


Fig. 7—Approximate correlation between single-suction impeller coefficient σ and specific speed.

high energy-storage system, direct-connected drives must be designed to withstand the maximum reverse runaway speed. Positive protection should be provided to prevent starting the driver under this reverse runaway condition.

On systems in which the pumping head is composed largely of friction losses, as in most condenser circulating-water systems, the head available for reverse rotation is usually low. If two pumps installed in parallel have one unit running and the other taking practically all the flow in reverse rotation, the resulting reverse runaway speed will be about 75 to 80 per cent of normal speed.

Some low-speed, low-head pumps in low energy-storage systems have been successfully started from reverse rotation. However, this process presents a severe shock to the equipment. The starting shock can be reduced by properly timing the opening of the discharge valve, so that the pump starts from standstill.

If the head available for reverse rotation is less than the total dynamic head, Fig. 5*b* gives the correction factors that must be applied to the value from Fig. 5*a* to estimate the actual reverse rotation speed.

Best Efficiency: Fig. 6 indicates the approximate maximum efficiency that can be expected for various specific speeds. On small pumps, roughness in the hydraulic passages and other boundary effects reduce efficiency. For this reason, higher efficiencies can be expected in larger pumps. Maximum efficiency drops sharply at the lower specific speeds. To increase low specific speeds to obtain better efficiency levels, the pump speed can be increased. If the optimum driver speed has been reached, additional stages can be added. For very low-capacity, very high-head operation which would call for an excessive number of small impellers, positive-displacement pumps should be used.

Inlet Requirements: Fig. 7 shows the approximate correlation between single-suction impeller-inlet requirements and specific speed at the impeller's maximum efficiency. Suction requirements are stated on this curve in terms of the coefficient σ, which is determined by laboratory tests. The coefficient is defined as

$$\sigma = \frac{h_{sv}}{H}$$

On large pumps, particularly those taking their suction from an open chamber or bay, suction requirements are usually stated in terms of feet of submergence. This value is measured vertically from the forebay surface to either the centerline of the impeller or the bottom of the suction bell. The usual practice on circulating-water pumps is to measure submergence to the bottom of the suction bell. Required submergence to the bottom of the pump-inlet bell can be calculated by subtracting atmospheric pressure from the sum of the net positive suction head required and the vertical distance from the centerline of the impeller to the bottom of the suction bell.

Cavitation: Fig. 8 shows the general pattern of break-off for various specific speeds as the coefficient σ is reduced. On these curves, two points are of

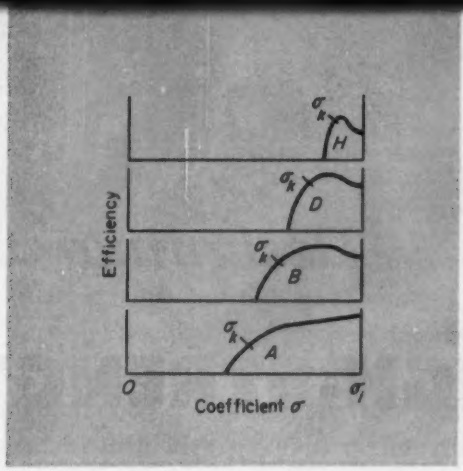


Fig. 8—General pattern of break-off for various specific speeds.

interest. The first is σ_k, the point of fully developed cavitation, and the point at which a pump begins to lose head and efficiency. The break-off point is very distinct at lower specific speeds but it is more gradual at higher specific speeds. Net positive suction head requirements tend to drop off as discharge flow is reduced, except for a sharp increase in the unstable zone shown in Fig. 2*a*.

The second point of interest on Fig. 8 is σ_i, the point of incipience of cavitation, or the point at which cavitation occurs at one point on the impeller. In order to provide enough net positive suction head to prevent pitting of the impeller, the coefficient σ should not be less than σ_i, the incipience-of-cavitation point.

In addition to the net positive suction head requirements, flow geometry to the impeller inlet affects smoothness of pump operation. Although the infinite number of possible variations in flow geometry prevent a direct correlation between rough operation and specific speed, the higher the specific speed, the rougher the pump operation when poor inlet-flow conditions are encountered. Rough operation can produce bearing beating, or input power swings, and should be avoided in high specific-speed pumps taking their suction from an open chamber or bay through an inlet bell, without the benefit of a pump casing to help guide the flow to the impeller.

Tips and Techniques

Vibration Patterns

Producing nodal patterns (Chladni's figures) by sprinkling sand on a vibrating part is limited to relatively flat surfaces. Using a mixture of polyvinyl chloride and magnesium stearate extends the use of this procedure to include curved surfaces.

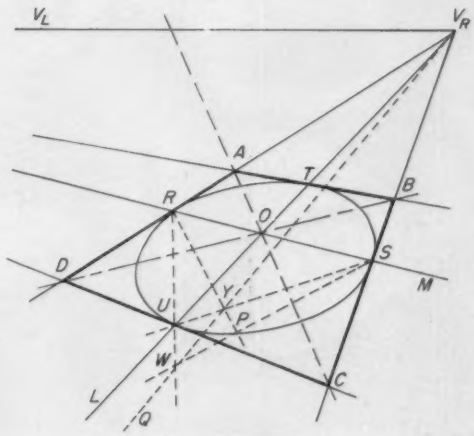
The PVC should be in fine pellet form—about 10 mu in. in size—mixed in the approximate ratio of 10 parts to 1 part of magnesium stearate. The oily nature of the stearate, which should be finer than the PVC in particle size, allows the mixture to cling to a curved vibrating surface. — ROBERT T. BOHM, *Lycoming Div., Avco Corp., Stratford, Conn.*

Circle in Perspective

This method can be used to plot points which determine a circle in a perspective square. The square is designated in the figure as *ABCD*.

1. Draw diagonals *AC* and *BD*, intersecting at center *O*.
2. From vanishing point V_L, draw V_LO, intersecting the square at *R* and *S*. From V_R, draw V_RO intersecting the square at *T* and *U*.
3. Draw an arbitrary construction line V_RQ. Draw *RU* and extended to intersect V_RQ at *W*. Draw *SU*, intersecting V_RQ at *Y*. Draw *SW*.
4. Draw *RY* and extend to intersect *SW* at point *P*, which is on the required ellipse. Repeat the same procedure above line *RS* using the same construction line V_RQ. Continue plotting pairs of points within quadrants *AOB* and *DOC*.
5. To plot points in the remaining quadrants use the same procedure from vanishing point V_L.

—W. H. SHEPPARD, *Montreal, Quebec.*



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Designing with

HIGH-STRENGTH CERAMICS

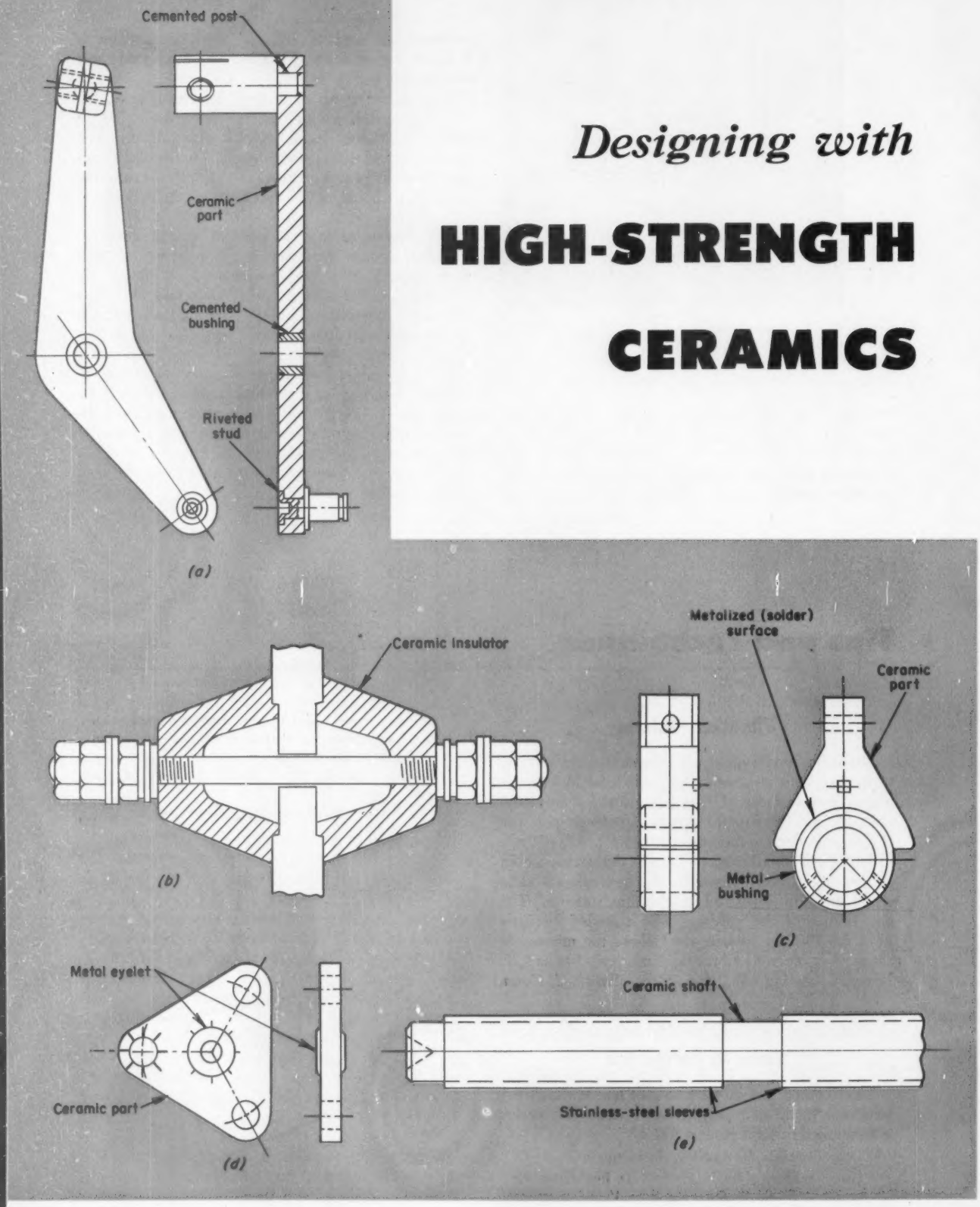


Fig. 1—Ceramic-to-metal attachments are made in many ways: Ceramic arm assembly, *a*, has one riveted and two cemented attachments; ceramic insulator, *b*, is assembled to its metal terminal with bolts; contact-arm assembly, *c*, has bushing attachment metalized to the ceramic part; insulator assembly, *d*, includes rolled-flange eyelet; rotor shaft assembly, *e*, consists of high-alumina ceramic shaft with stainless-steel sleeves pressed on.

The old concept of ceramics—materials only for insulating—is obsolete. Many ceramic materials have strength, chemical resistance, and hardness properties that qualify them for use in precision and high-performance applications such as bearings, valve seats, and pistons. Some high-alumina ceramics can operate continuously at 2700 F—and still maintain their high mechanical strength. This article, developed and written by the Ceramic Engineering Dept. of Centralab, Electronics Div. of Globe-Union Inc., Milwaukee, Wis., presents design recommendations for two of these materials—steatite and high alumina.

COMPLETELY inert in the presence of alkalies, petroleum products, gases, and acids (except hydrofluoric), steatite and high-alumina ceramics can be used where many other materials would be ineffective. These ceramics are also uneffected by oxidation, corrosion, and fungus growth. The additional properties of high strength and abrasion resistance make them particularly useful for components of measuring instruments and other dimensionally critical devices.

Materials

Of the many ceramic materials, prominent from the standpoints of strength, economy, and corrosion resistance are the high-alumina and steatite ceramics.

High Alumina: Ceramics in the high-alumina group are basically composed of 85 to 99+ per cent alumina (Al_2O_3). The balance of the material consists primarily of controlled amounts of silicon, magnesium and calcium-oxide complexes. Generally, mechanical strength and high-temperature resistance increase with alumina content, Table 1.

Steatite: Compositions of magnesium metasilicate ($MgO \cdot SiO_2$) are known as steatite. Strength, operating-temperature limits, and cost of steatite are lower than those of high-alumina ceramics.

Process

Ceramics are generally fabricated by pressing or extruding. The materials are suited for rapid pro-

Table 1—Properties of Ceramics

Property	Alumina (per cent Al_2O_3) 85	95	99	Steatite
Flexural Strength (psi)	35,000*	43,000*	54,000*	20,000‡
Compressive Strength (psi)	250,000*	300,000*	300,000*	85,000†
Impact Resistance, Charpy, 0.5 in. diam (lb-in.)	6	7	8	4.7
Hardness, Moh's Scale	8–9	9	9	7.5
Temperature, max continuous (F)	2,000	2,500	2,700	1,800
Thermal Conductivity at 100 C (cal/sec/sq cm/deg C/cm)	0.034	0.053	....	0.006
Linear Coefficient of Thermal Expansion (per deg C)				
20-200 C	5.6×10^{-6}	5.7×10^{-6}	6.43×10^{-6}	7.7×10^{-6}
20-400 C	6.1×10^{-6}	6.25×10^{-6}	7.21×10^{-6}	8.0×10^{-6}
20-600 C	6.55×10^{-6}	6.7×10^{-6}	7.81×10^{-6}	8.2×10^{-6}
Temperature Coefficient of Capacity Change, 25-85 C (ppm)	+120	+130	....	+120
Apparent Specific Gravity	3.45	3.75	3.83	2.62
Porosity (per cent water absorption)	0–0.02	0–0.02	0–0.2	0–0.02
Fuchsine Dye Jan 1-10	Impervious	Impervious	Impervious	Impervious
Dielectric Constant (at 10^6 cps)	8.7	9.3	9.3	5.58
Power Factor (at 10^6 cps)	0.0002	0.0002	0.0002	0.00075
Loss Factor (at 10^6 cps)	0.002	0.002	0.002	0.00419
Rating, JAN-I-10 Grade	L&A	L&A	L&A	L&A
Dielectric Strength at 25 C, 1/16 in. thick (v/mil)	250	285	325	250‡

*Test sample, $\frac{1}{2}$ in. diam.
†Test sample, $\frac{3}{4}$ in. diam.
‡Tested to JAN I-10 specifications.
‡Thickness, $\frac{1}{4}$ in.

duction of small parts on automatic presses.

To vitrify the ceramic, its temperature is gradually raised to the maturing point (as high as 3200 F), held there, then reduced. Firing cycles vary from 15 to 40 hr.

Both fired and unfired ceramic parts can be machined, and the stage at which machining is done depends largely on required tolerances. Unfired material can be drilled, tapped, or threaded. Operations such as diameter reduction and undercutting, not possible in extruding, are done by turning.

Large, complex ceramic shapes can be formed on hydraulic presses with a high degree of accuracy. To maintain quality, however, the units must be formed individually—not by mass-production techniques.

After firing, the ceramic is extremely hard, and close tolerances can be obtained only by grinding with diamond wheels. Grinding of fired parts is relatively expensive.

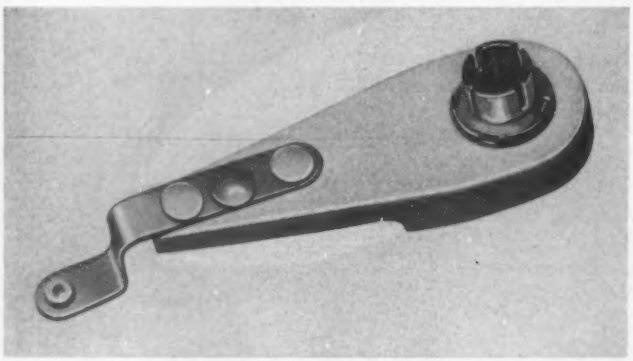
Attachment

Just as there is no "best method" of attaching metals to each other, there is no "best method" of attaching metal to ceramic. Methods depend on specific application.

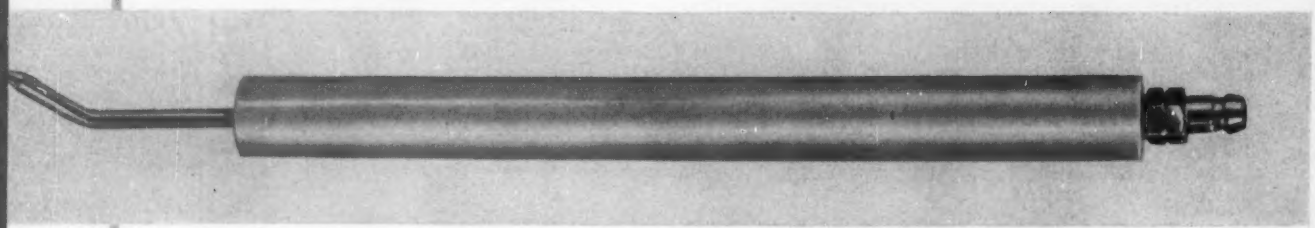
Cementing: Many high-temperature resistant cements are available for use as a basic attachment medium. These high-strength cements can be used for almost all types of ceramic-to-metal and ceramic-to-ceramic attachment, Fig. 1*a*.

Bolting: Since threaded holes can be fabricated into the ceramic part, either metal or ceramic bolts can be used for attachment. Metal studs and bolts are also used to assemble multipart ceramic assemblies, Fig. 1*b*.

Metalizing: Silver can be bonded to the surface of a steatite or high alumina part by firing. The silver layer is then plated with any of a wide variety of metals, including soft solder, Fig. 1*c*. For metalized parts that must withstand high temperature, special alloys are available for bonding to the ceramic. Thermal stability of the bond is limited only by the temperature resistance of the alloys that are brazed to it. Metalizing is the preferred technique where hermetic sealing is necessary or where attach-



Contact-rotor assembly for television tuner includes two ceramic - to - metal attachments. Nickel-plated brass bushing, right, is soldered to the metalized alumina part; contact arm, left, is fastened by riveting.



Electrode for oil-burner is fastened to ceramic cylinder by staking. Contact end of electrode, left, is threaded.

ment of electrical leads is involved.

Eyeleting: When a hollow ceramic part surrounds a metal attachment, the metal part can be spun over to form a tight engagement between the parts, Fig. 1*d*.

Shrinking: When a metal attachment surrounds the external diameter of a ceramic part, a shrink-fit technique is often used. The metal is heated, slipped over the ceramic part, and allowed to cool.

Pressing: Used in the same types of applications as the shrink-fit method, pressing provides a stronger attachment, Fig. 1*e*. The pressed attachment method is more expensive than the shrink-fit technique, since machining of both parts is required.

Design

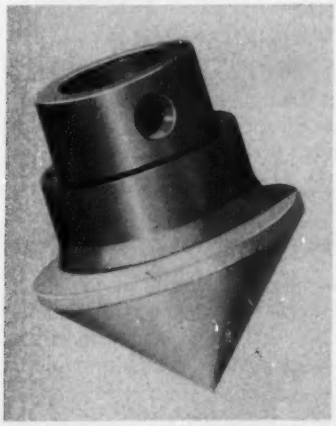
Tolerances, design considerations, and fabricating techniques of ceramic materials differ from those of most other engineering materials.

Tolerances: Decimal dimensions of ±1 per cent, but not less than ±0.005 in., can be held with standard manufacturing procedures. Fractional dimensions are normally specified with tolerances of ±2 per cent, but not less than ±1/64 in. Because of shrinkage during firing, closer tolerances can be achieved only by a subsequent grinding operation.

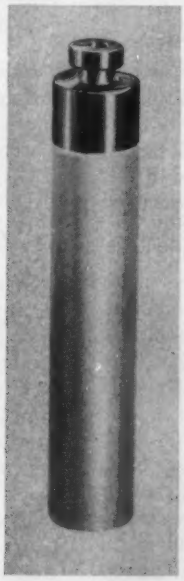
For economy and firing stability, the ceramic part should be as simple as possible. Variations of level or thickness create density differences, thus increasing camber and the risk of cracking. As with most materials, tooling and fabricating costs are proportional to part complexity.

Fillets and Wall Thickness: Inside corners should be provided with a minimum of 0.010 in. radius, Fig. 2*a*, to increase the strength of the part and to reduce risk of cracking. The radius or angle of each fillet should be specified. Wall thickness of ceramic tubes should be at least 10 per cent of the tube diameter. Thinner tube walls require special handling and machining of the part.

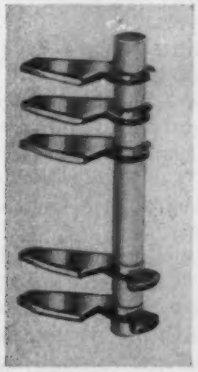
Holes and Threads: If holes and counterbores are placed too close together or too near the edge of a part, cracks usually develop in the drying and fir-



Chemically inert valve seat of high-alumina ceramic is used in glass-lined system carrying hot alcoholic liquids. Metalized ceramic cone is brazed to copper-plated bushing.



Pump-plunger assembly is used in systems that handle corrosive liquids. The stainless-steel connector piece is cemented to the ceramic cylinder. Plunger diameter is finish ground to 0.0002 in. total indicator reading and polished to a surface finish of 10 mu in.



Rotor assembly for variable capacitor depends on metalizing for ceramic-to-metal attachments. Capacitor blades are soldered to metalized areas, and spacing is held to ± 1/64 in.

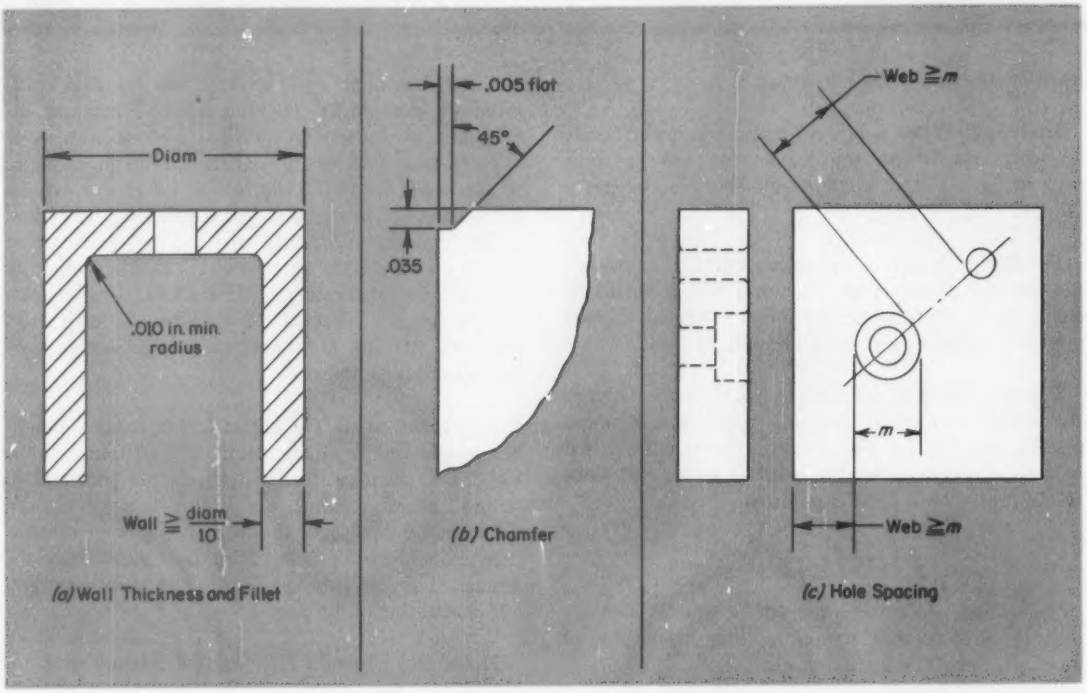


Fig. 2—Detailed design recommendations for ceramic parts.

ing processes. Thickness of intervening webs should equal or exceed the diameter of the hole or counterbore, Fig. 2c.

Threads should have a radius or flat at the root and should be specified as Class 1 fit when possible. Class 2 fits can be used if required, but should be avoided due to additional cost.

Gaging conditions for ceramic screws are: 1. Standard "Go" ring gage must pass. 2. Tolerance of OD to be ±1 per cent or ±0.005 in., whichever is greater.

Gaging conditions for ceramic nuts are: 1. Standard "Go" thread member must pass. 2. Rod of diameter equal to pitch diameter of nut must not pass.

All holes, whether tapped or smooth, should be chamfered or counterbored at the surface to reduce possibility of chipping. All outside corners should be chamfered or radiused for the same reason.

Glazing: A glazed surface is easier to keep clean than an unglazed one. Physical properties of ceramic parts are not affected by this surface treatment. When possible, glazing should be applied before firing to eliminate an additional operation. The external surface on which the part rests during firing must remain unglazed. In general, for industrial applications, glazing is unnecessary.

Flatness: Surface flatness must be expressed by a maximum decimal or fraction. Parallelity is considered satisfactory when thickness is within the thickness tolerance of the part, even though it is at minimum thickness at one point and maximum at another.

Imperfections: Chips, blisters, pimples, and other surface imperfections are recognized by both military and commercial specifications and are acceptable when they do not impair performance.

Self-Optimizing Control Systems

Several corrections should be made in the recent series of articles by J. M. Nightingale. In Equation 9 of Part 2, Sept. 15, 1960, the multiplication sign in the first line of the equation should be replaced by a plus sign.

In Part 3, Sept. 29, 1960, the right side of the transfer function equation which approximates the system shown in Fig. 11 should read $(\omega/\omega_b)^2$. The Q of the transfer function which approximates the dynamic effect of the bandpass filter should be $Q = 4g/5$. The last item in the left side of the resulting equation should be $2K\alpha\Omega\Delta\lambda\xi$.

The average value of the increase in mean square error should be

$$\overline{\delta E} = A\sqrt{2\omega_c}$$

Spectral density of the noise should be $\Phi_n(\omega) = Nv/(\omega^2 + v^2)$ which will revise Equation 14 to $E' = E + N[1-2H(s)]_{s=jv}$

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Silicon Power Rectifiers

Silicon rectifiers can solve temperature and space problems under high-voltage or high-amperage conditions. With attention to a few design precautions, they can be grouped effectively in series or parallel circuits to deal with high-power applications.

SILICON rectifiers are now used in products ranging from truck generators and aircraft components to plating rectifiers, welders, and battery chargers. In high-power applications they can take their place with germanium, selenium, and copper-oxide rectifiers, mercury-arc tubes, and motor-generator sets. Most circuitry and cell-protection problems that had impeded progress in applications of silicon rectifiers are now solved. Some proven applications are operating in the 2500-kw range.

Efficiency and Regulation

Typical silicon-rectifier equipment has efficiency of 93 to 96 per cent. Mercury tubes reach this figure only when operated at 600 v or more. For selenium rectifiers and motor-generator sets the efficiency falls below 90 per cent. Typical efficiency vs. rated output voltage is plotted for various types of conversion equipment in Fig. 1.

Possibly more important from a design standpoint is the fact that silicon-rectifier efficiency changes very little through a wide range of loads. Consequently, losses at reduced load are very light. Fig. 2 shows that in the range from 25 to 100 per cent of rated load, the efficiency of a typical silicon rectifier varies as little as 1 per cent.

Environmental Tolerance

Brazed or welded joints in silicon rectifiers make a shock and vibration-resistant unit. The rectifying junction is hermetically sealed against fumes or salt spray. Usually the exterior is painted

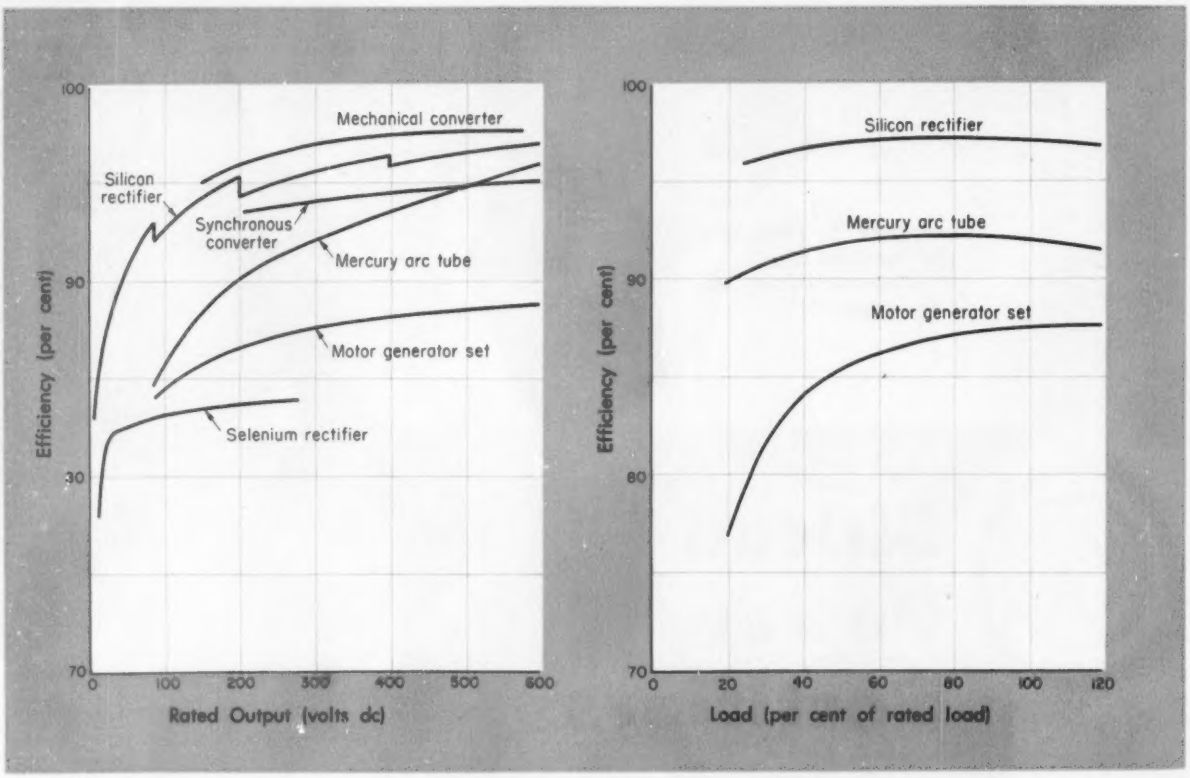


Fig. 1—Typical full load efficiency vs rated output voltage for various types of conversion equipment.

Fig. 2—Voltage ratio vs rated load for various types of conversion equipment.

or plated. To damage the hermetic seal, sustained currents one hundred times normal rectifier rating would have to be involved. Where this is possible, current-limiting fuses are recommended.

Design Points To Watch

Circuit Type: If a single phase center-tap circuit is used, the peak reverse voltage will be twice that of a single-phase bridge with the same d-c output voltage. The rms current per cell for a given average current is much higher in a six-phase star circuit than it is in a three-phase double wye circuit. For these reasons the type of circuit must be known.

Surge Voltages and Overloads: In normal applications where transformers may be switched on and off, a 3:1 ratio between rated PIV (peak inverse voltage) and operating PIV is recommended. If surge suppressors are used to limit switching transients, this ratio may be reduced, but not below 3:2. Besides switching transients, surges may come from the load or other equipment on the power line.

The overload requirements will generally establish the maximum continuous current at which silicon rectifiers can be applied. The small thermal mass of silicon limits the one-cycle fault rating to approximately five to ten times the maximum continuous rating. Some applications have little or no overload requirements, but industrial equipment—motors, welders, battery chargers, and arc furnaces—does require overload capacity. Quite often the short-time fault-current requirements limit the current at which the cell is applied continuously.

The application will generally determine the type of overload protection to be used. A welder or battery charger is subject to frequent short circuits. Fuses are not satisfactory, therefore, and circuit breakers are used. But in electrochemical or utility rectifiers, fuses are used to limit current.

Cells in Series: The operating voltage in many applications will require that more than one cell in series be used. If this is necessary, the proper division of voltage must be obtained. Four methods of operating silicon rectifying cells in series are currently being used in high-voltage applications:

- Matching reverse characteristics.
- Adding resistive voltage dividers.
- Adding capacitive voltage dividers.
- Special designs.

Reverse characteristics must be matched if cells

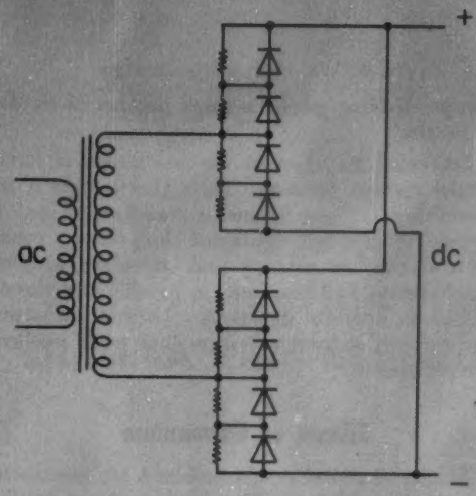


Fig. 3—Resistors used for equal division of reverse voltage.

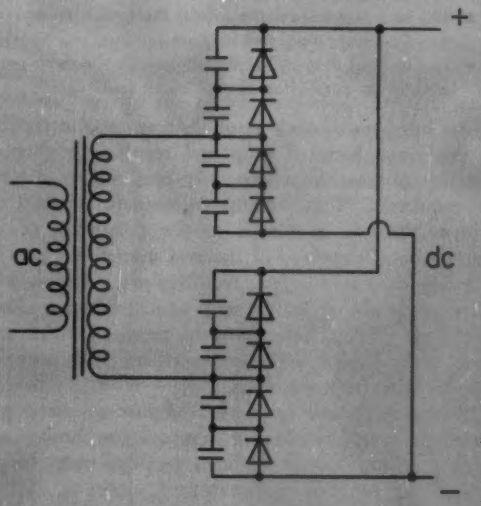


Fig. 4—Capacitive voltage dividers.

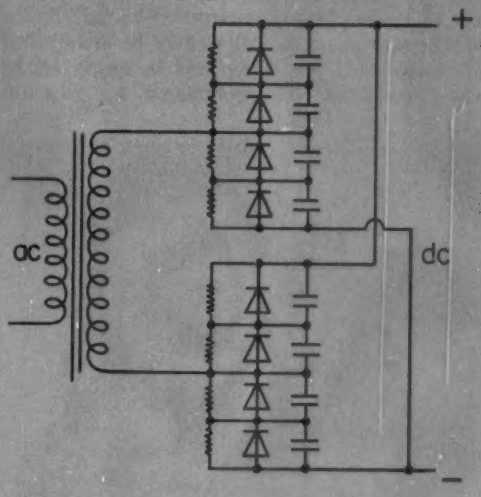


Fig. 5—Combined capacitive and resistance voltage dividers.

are to be used in series without a voltage divider. The cells need similar breakdown characteristics and reverse temperature coefficients. Cells with sharp avalanche-breakdown knees should not be placed in series with cells with soft knees.

Cells in a series string may differ and cause extreme unbalance when a reverse voltage is suddenly applied. The problem of unequal recovery times and the difficulty encountered in matching breakdown and temperature characteristics are reasons for the general recommendation that voltage dividers be used with two or more cells connected in series.

Resistive voltage dividers operate well in applications with moderate voltage requirements. A resistance is placed in parallel with each cell in the series, Fig. 3.

Capacitive voltage dividers can be similarly used in circuits where more severe conditions are anticipated, Fig. 4. Capacitances are placed in parallel with each cell in a manner analogous to the arrangement of resistances in the resistance voltage divider. In special cases both types may be needed simultaneously, Fig. 5.

Multiple transformer secondary windings like those in Fig. 6 may solve the problem where there are not a great many rectifiers in series.

Cells in Parallel: When silicon rectifiers are connected in parallel for increased current capacity, the low forward drop becomes a problem. Slight variations in forward drop cause large variations in the load carried by each cell, Fig. 7. Proper division of current among the cells may be obtained by:

- Matching forward characteristics.
- Adding a resistance or reactance in series with each cell.
- Balancing transformers or separate transformer windings for each cell.

Matching forward characteristics is the most obvious solution. However, cells matched at one point may have different forward drop vs forward current slopes and therefore may not divide the current evenly under all conditions. Matching characteristics call for a larger stock maintained by the supplier. It is hard to balance line impedance sufficiently to place more than six matched cells in parallel. With matched cells, the unbalance may be 25 per cent of the average current per cell; therefore, rectifiers should be operated at 75 per cent of the rated load.

Adding a resistance or reactance in series with the cell makes the slope of the effective forward drop vs forward current curve steeper, Fig. 8. This narrows the current difference between cells operating at a common voltage drop. By adding about 0.4 v to the peak forward drop of the cells, unbalance can be limited to 20 per cent, and the rectifier can operate at 80 per cent of rated load. Although they add more regulation to the circuit, the resistors offer better protection during overload or fault conditions than do matched cells.

Separate transformer windings can do a good

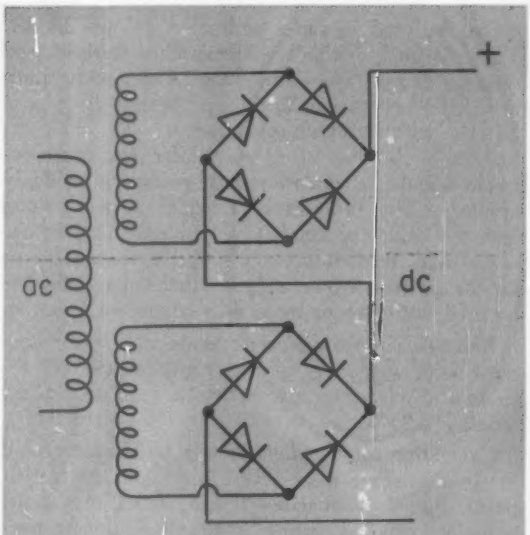


Fig. 6—Series outputs with separate inputs through use of multiple transformer secondary windings.

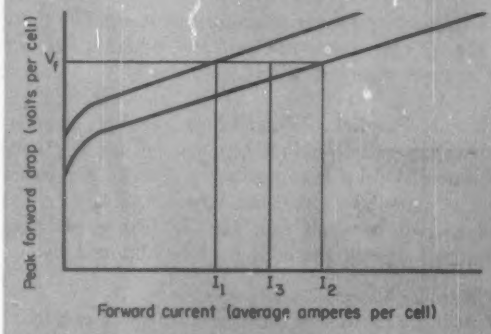


Fig. 7—Load characteristics of two unmatched medium-power silicon rectifying cells.

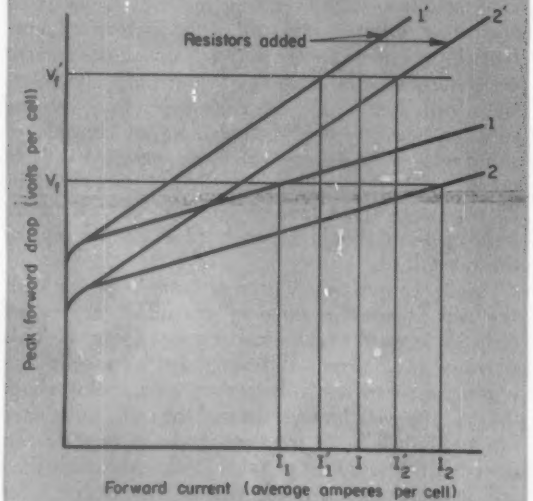


Fig. 8—Load characteristics of two unmatched medium power silicon rectifying cells with and without resistance added in series with each cell.

current-dividing job for a small number of rectifiers in parallel.

Balancing transformers are one means of forcing proper current balance. Their effectiveness is well established. These balancing transformers, or "reactors," consist of laminated iron cores, usually with single-turn primary and secondary windings. The currents from two cells in parallel pass through a core in opposite directions. Unbalance between the currents induces a voltage that tends to correct the unbalance.

Silicon vs Germanium

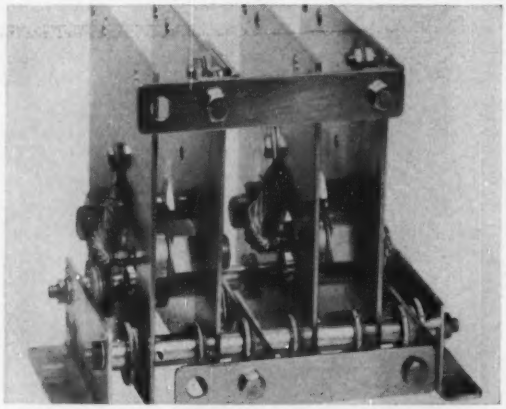
Similar electrical design problems are encountered in selecting either a silicon or germanium rectifier:

- Each is sensitive to transient overvoltages. Fuses and surge limiting devices must be included in the design that prescribes their use.
- The reverse characteristics require the same consideration if cells are connected in series.
- The forward drop characteristics require the same precautions in paralleling two or more cells.

An inherent advantage of the germanium rectifier is the lower forward drop and resulting higher efficiency obtainable where only one cell in a series is required. This advantage cannot be met by silicon since it is related to the properties of the energy-band structure of the two materials.

Large-area germanium rectifiers are available with current ratings up to 500 amp vs 250 amp for silicon rectifiers. They have been in production for several years longer. Silicon rectifiers will probably appear with higher ratings.

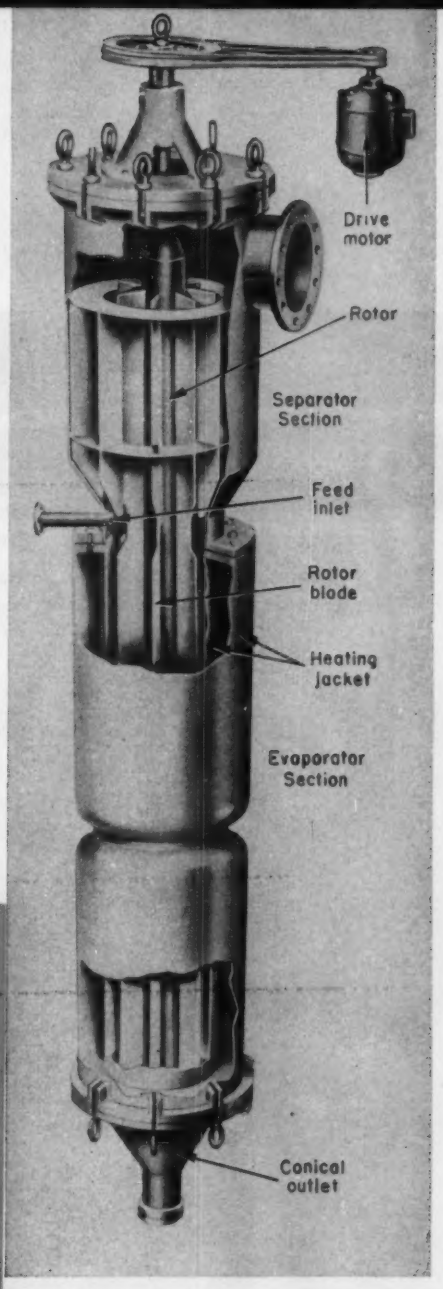
Silicon rectifiers have two advantages over germanium rectifiers—higher temperature limits, and higher voltage limits. Silicon rectifiers may be operated at junction temperatures close to 200 C. Germanium rectifiers are limited to less than 100 C. Until recently, the efficiencies of the two types of rectifiers were essentially equal if more than one cell in series were necessary. Now silicon, with voltage ratings up to 600 v, may be more efficient. Silicon rectifiers are being used in nearly all high-power areas formerly dominated by germanium.



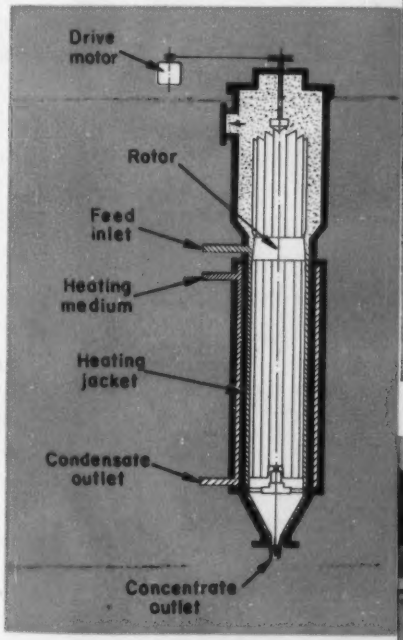
Copper cooling plates keep junction temperatures below 200 C in silicon rectifier cells mounted on them.

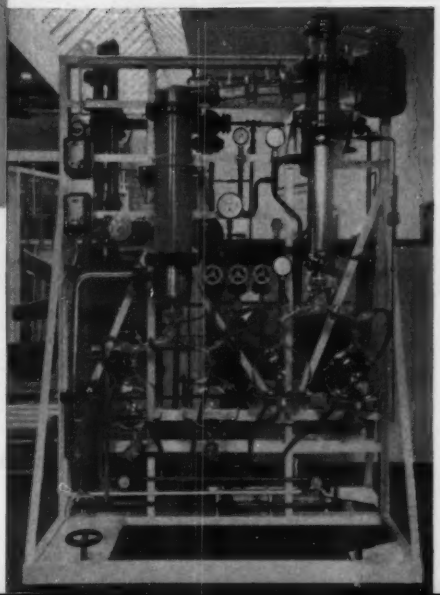
Rotor Spreads Thin Film In Quick-Acting Evaporator

FLUID IS FLUNG against the heated sidewalls of an evaporator in a thin, turbulent film for fast evaporating action. Gravity draws the fluid through the evaporator section in less than a minute. For most processes one pass does a complete job. Unevaporated portion is drawn off. Vapor is removed from the top of the machine. Entrained moisture is removed centrifugally in the separator section with extra wide blades.



HEATING MEDIUM is steam, oil, or diphenyl-oil vapor depending on the needs of the evaporating job being done. Working pressure can be varied over wide limits, but remains fairly constant over heat-transfer surfaces.



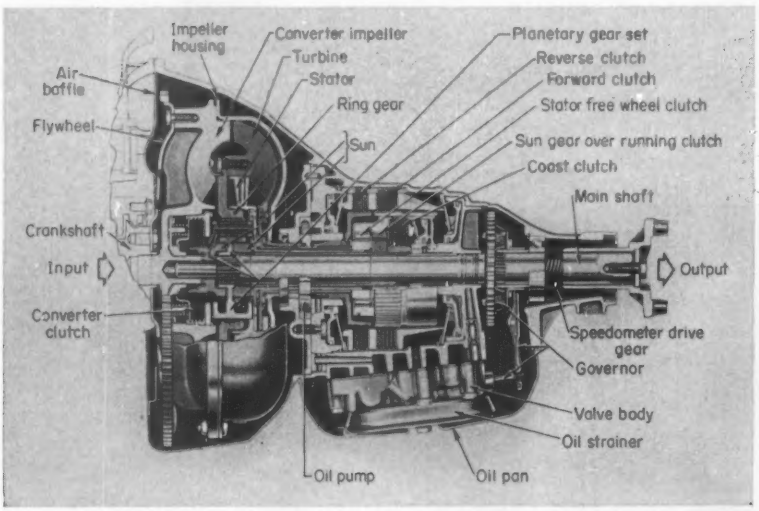


THIN-LAYER EVAPORATING MACHINE can be adapted to most problems of evaporating or distilling. The machine includes material feed, evaporating unit, condenser, product removal, and vacuum equipment. Rotor is driven by an electric motor through a V-belt. Design is by Luwa AG, Zurich, Switzerland.

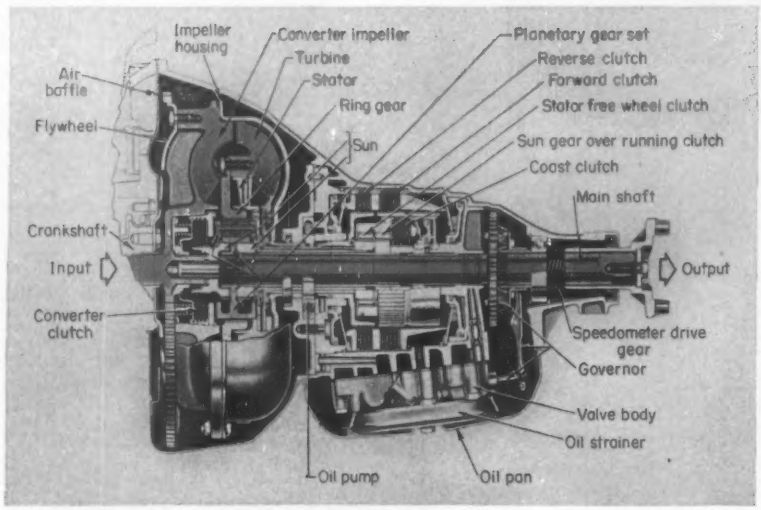
NEW TRANSMISSION was designed for the Special. Buick engineers say, however, the principle could be used easily on any Buick.

Clutch Splits Power Path

SHIFT FROM LOW TO HIGH, in a transmission designed for the new Buick Special, is accomplished by splitting the power path with a converter clutch. At a predetermined speed the converter clutch engages and transfers 36.6 per cent of the input torque directly to the sun gear. The remaining 63.4 per cent continues to be transmitted hydraulically through the torque converter and is eventually applied to the ring gear.



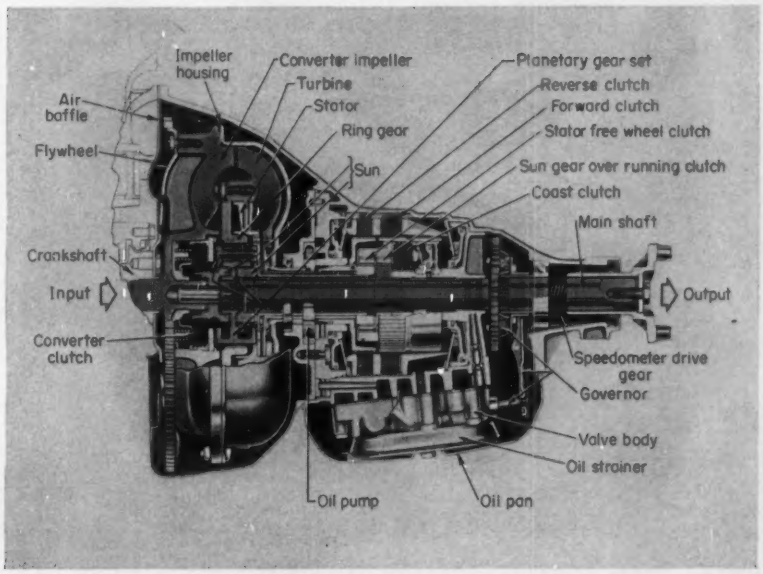
IN LOW RANGE, power is transmitted entirely through the one-stage torque converter. Ring gear of the planetary system is attached directly to the turbine. Output is from the planetary armature.



Low Forward

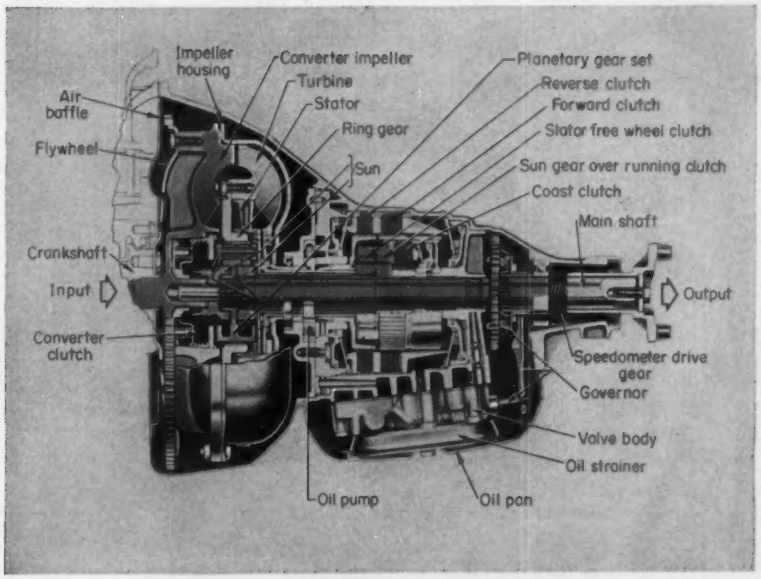
In Buick Special Transmission

CONVERTER CLUTCH COUPLES the sun gear to the crankshaft in high range. Sun gear overruns the stator by means of the sun gear overrunning clutch, while the hydraulic coupling remains unchanged.



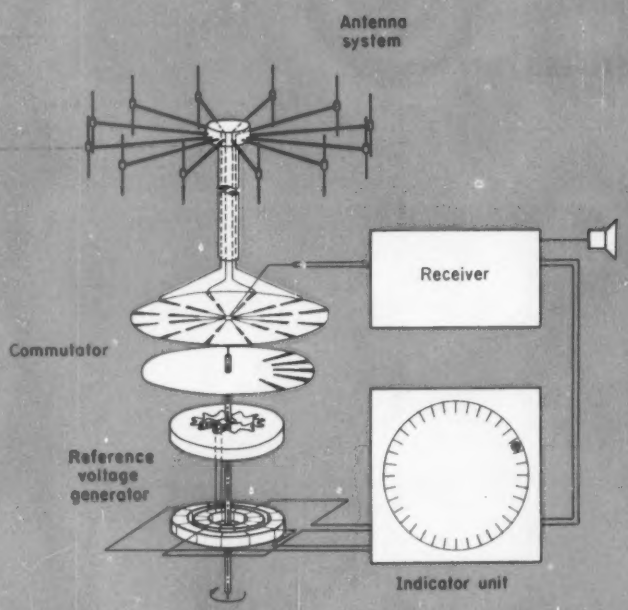
High Forward

TURBINE CHANGES ROLES with the stator for reverse drive. Reverse clutch immobilizes the turbine and ring gear while the stator drives the sun gear in reverse.

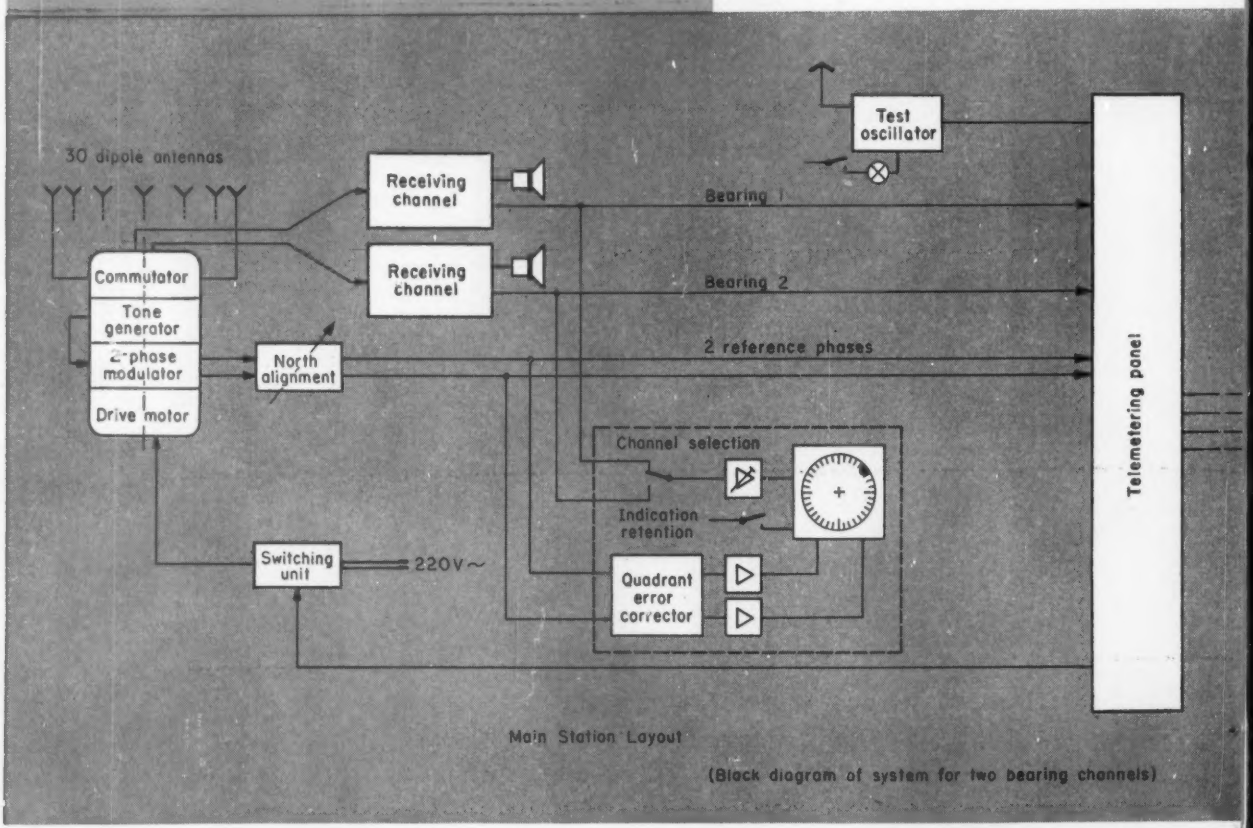


Reverse

Direction Finder



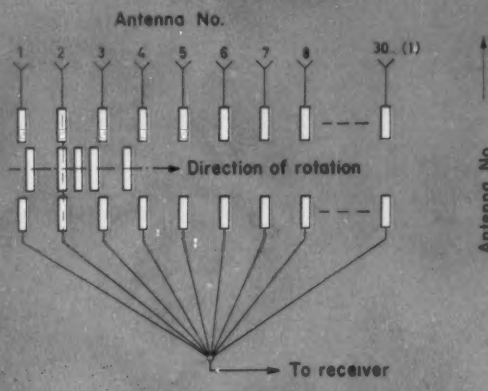
ILLUSION OF MOTION of receiving antenna is created in a new radio direction-finding station by scanning leads from three or four antennae in rapid succession. The resulting "doppler" effect helps locate the azimuth of incoming signals. Dipole antennae are arranged in a circle at the ends of radiating supporting arms. Leads pass down through a hollow mast.

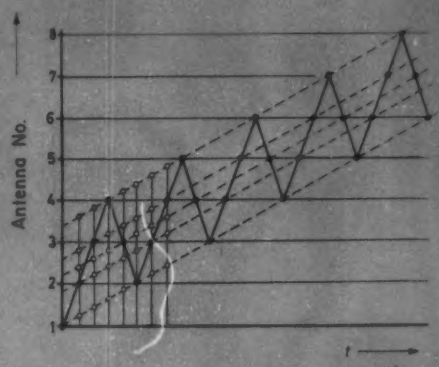


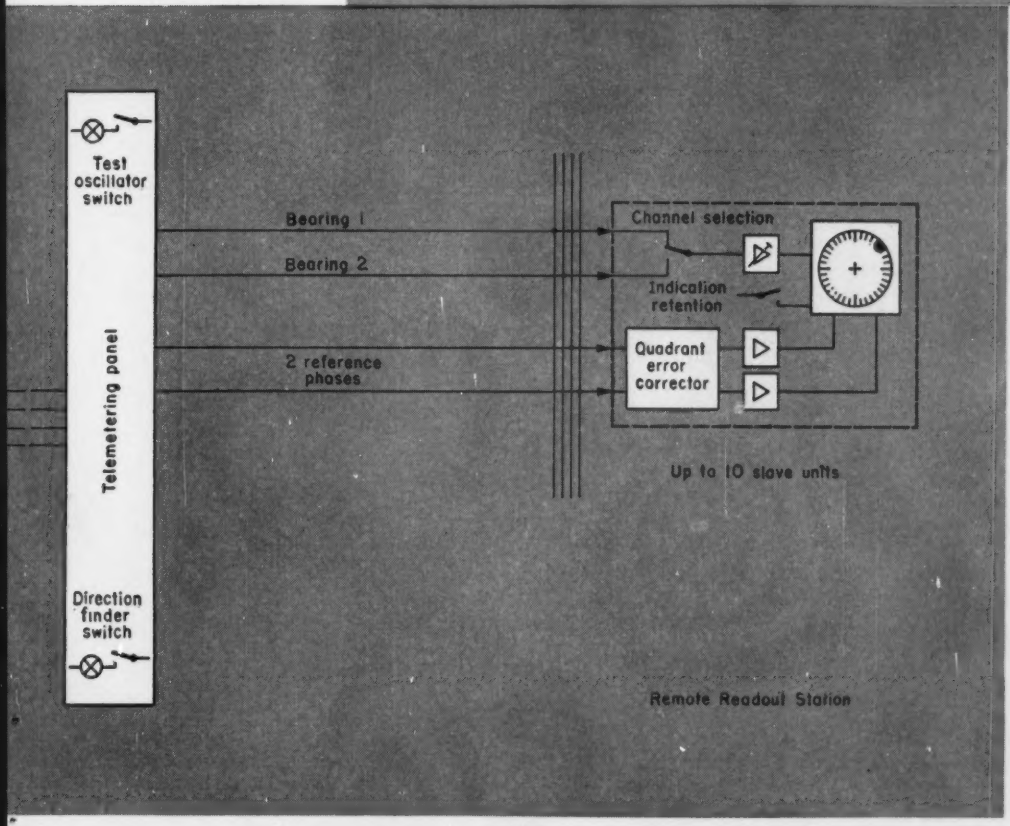
Main Station Layout

(Block diagram of system for two bearing channels)

Checks Azimuth With Simulated Doppler Effect



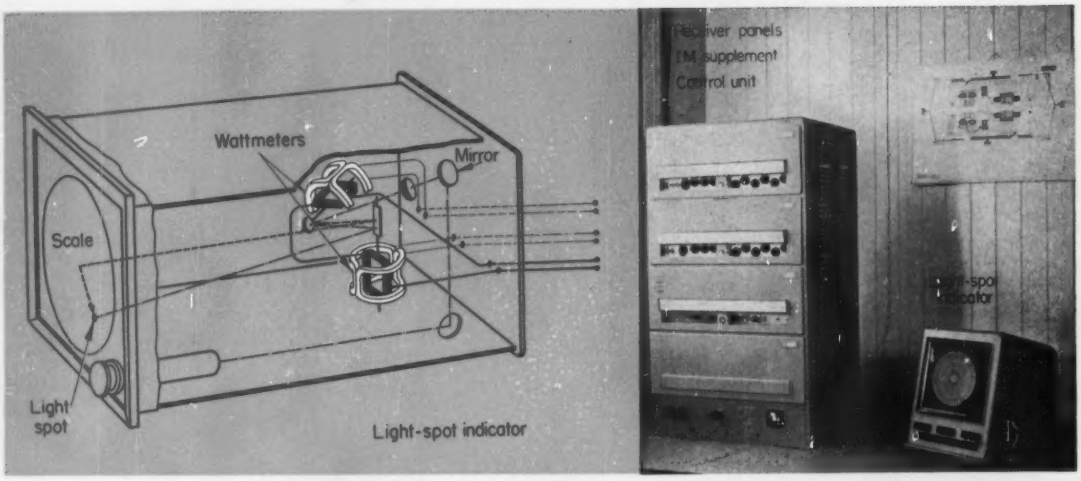




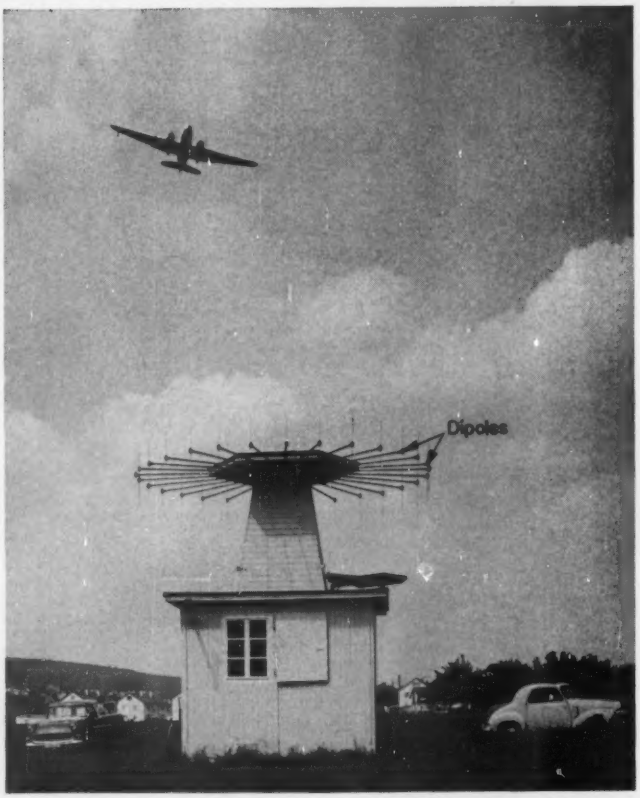
SYSTEM IS SCANNED by a commutator with five capacitive contacts so arranged that as the rotor progresses it makes three successive forward contact steps followed by two steps back for a net advance of one contact.

UP TO TEN airports can use a centrally located station by installing duplicate readout units and appropriate quadrant error correcting equipment. Receiving equipment for direction finding can operate either on AM or FM signals. For clarity, only two channels are shown in the diagram.

Direction Finder Checks Azimuth With Simulated Doppler Effect



INPUT BEARING SIGNAL is combined with a station-generated reference signal by wattmeters to operate the readout device. What looks at first like an oscilloscope face is really a ground-glass screen on which is projected a point of light. Mirrors rotated by the wattmeters position the point of light.



DOPPLER DIRECTION FINDER is a development of Standard Elektrik Lorenz AG, Stuttgart, Germany.

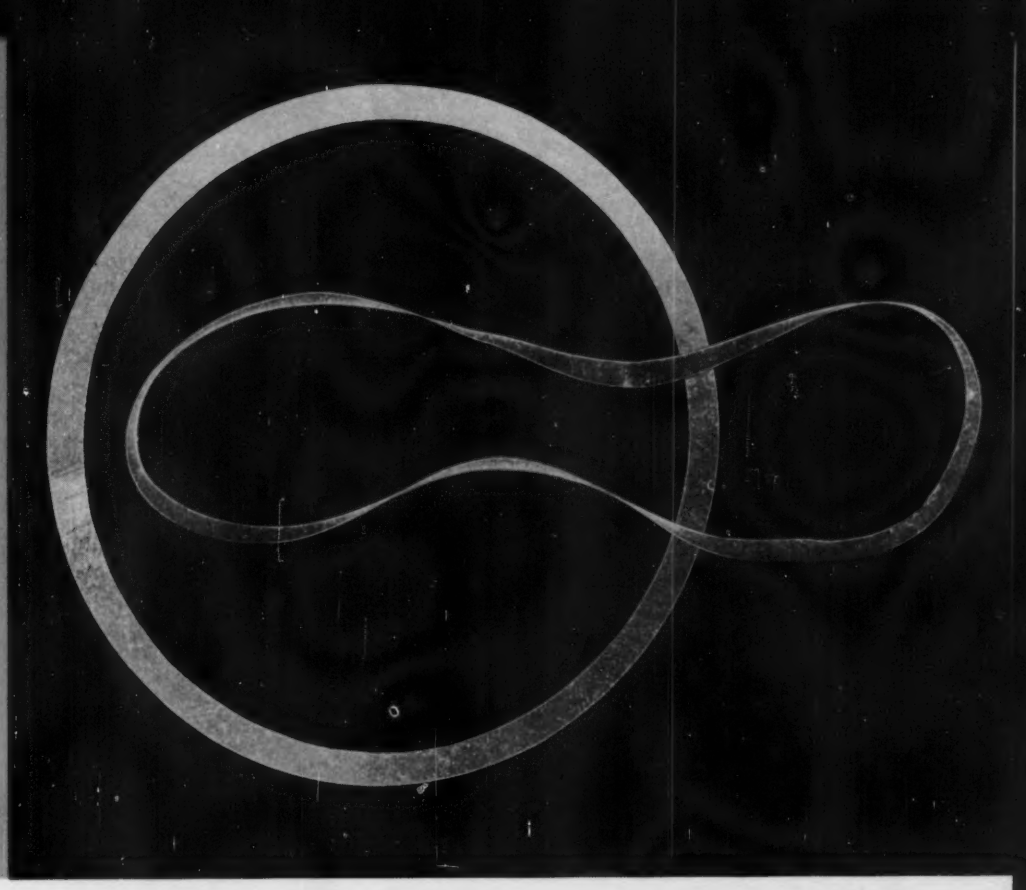


Fig. 1 — Belt fabrication involves stretching and orienting the fibers of a washer-shaped ring into a stable width of continuous belting.

Polyester-Film Belts

Precision drives for satellite tape recorders sparked this new development in belt design.

Novel but practical, these thin plastic belts can operate over pulleys as tiny as 0.040-in. diameter, at surface speeds of 2000 fpm, or can transmit 10 hp from a 2-in. pulley diameter at speeds of 3000 rpm.

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Head
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Washington, D. C.

FATIGUE resistance, high strength, uniformity, and ability to be driven by extremely small pulleys are some of the properties which make polyester-film belts attractive for mechanical-instrumentation and power-transmission applications.

This article indicates actual performance based on a limited number of tests, suggests design criteria, and describes fabrication procedure and applications.

The belts reported on here, Fig. 1, have an essentially flat and homogeneous cross section and are fabricated from sheet Mylar (Du Pont) in thick-

nesses of ½ mil to 10 mils. A few properties of this material are given in Table 1. The values represent typical or average test data, not minimum design values.

Transmission Uniformity

Uniform power transmission is foremost on the list of desirable characteristics of polyester-film belts. This characteristic is a result of the exceptionally small variation in belt thickness. Pitch-line variation as small as 0.0001 in. can be obtained without difficulty, whereas high-quality fabric belts, as applied in high-performance tape recorders, exhibit variations of pitch line in the order of 0.001-in.

The effect of variation of belt thickness on instantaneous angular speed ratio of a drive system, where dynamic effects are neglected, can be shown. The basic relation between driven-pulley speed ω_2 and driving-pulley speed ω_1 is

$$\omega_2 = \omega_1 \frac{2r_1 + t}{2r_2 + t} \qquad (1)$$

The most unfavorable condition of thickness variation exists when belt thickness increases over the driven pulley by an amount Δt, and decreases over the driving pulley by the same amount Δt, or vice versa. The maximum change in ω_2 for this condition is

$$\Delta\omega_2 = \frac{\Delta t(r_2 + r_1)\omega_1}{2r_2^2} \qquad (2)$$

where belt thickness is small compared to pulley radii.

If belt thickness is neglected in Equation 1, and Equation 1 is divided into Equation 2,

$$\frac{\Delta\omega_2}{\omega_2} = \frac{\Delta t(r_2 + r_1)}{2\,r_2\,r_1} \qquad (3)$$

This expression in per cent represents a possible component of "flutter" or instantaneous speed variation in recorder or instrument drives.

Although the geometric variations of friction drives are also small theoretically, friction drives are susceptible to permanent and semipermanent surface deformations caused by temperature variation and local stresses. The deformation and hardening of the rubber (or plastic) at low temperatures result in both instantaneous and long-term torque fluctuations which cause speed variations.

Because of the flexibility and because of the negligible forces required to bend the polyester film over small radii, the only significant source of power loss in the drive system is the loss in the bearings from belt tension. Better than 98 per cent efficiency can be obtained in extremely compact designs. For example, operation of the record drive system of the Vanguard II recorder* was obtained with only 100 milliwatts of electrical power input.

*"Tracking Earth's Weather and Cloud-Cover Satellites," *Electronics*, May 1, 1959, by R. Hanel, R. A. Stampfl, J. Cressey, J. Licht, E. Rich.

Torque Capacity

Relatively high-speed characteristics and torque capacity are a result of high allowable stress and high strength to weight ratio. Also, oriented polyester-film belts have a linear stress-strain relationship, Fig. 2. Tests of heat-treated belts, 0.005-in. thick, showed that the linear relationship prevailed up to approximately 15,000 psi, with a yield point of about 17,000 psi. Because of the linear stress-strain characteristic, stress S is equal to $C\Delta l$ where C is a constant (modulus divided by length) and Δl is elongation. If the increase of stretch on the tight side is equal to the decrease of stretch on the slack side,

$$\frac{1}{2} l\Delta l_1 + \frac{1}{2} l\Delta l_2 = l\Delta l_0 \qquad (4)$$

where Δl_1 and Δl_2 are the elongations of the tight side and slack side, respectively, Δl_0 is initial elongation, and l is total length. When S/C replaces Δl and Equation 4 is multiplied by the cross-sectional area,

Table 1—Properties of Polyester Film

Property	Typical Value
Tensile strength (psi)	20,000
Tensile modulus (psi)	550,000
Density (gm per cc)	1.39
Moisture absorption (per cent)	Less than 0.5
Shrinkage at 150 C (per cent)	2 to 3
Melting point (C)	250 to 225
Service temperature (C)	−60 to 150

Data for 1-mil thick Mylar, courtesy E. I. du Pont de Nemours & Co.

Nomenclature

C = A constant
D = Diameter, in.
E = Modulus of elasticity, psi
g = Acceleration of gravity, 386 in. per sec²
l = Length of belt along pitch line, in.
M = Torque, lb-ft
N = Angular speed, rpm
P = Power, hp
r, r_1, r_2 = Pulley radii, in. or ft
S = Stress in extreme fiber of belt, psi
T_0, T_1, T_2 = Initial tension, tight-side tension, and slack-side tension, lb or oz
t = Belt thickness, mils or in.
v = Velocity, in. per sec
β = Arc of belt contact, rad
γ = Density, lb per cu in.
θ = Portion of arc of contact, rad
μ = Coefficient of friction
ω_1, ω_2 = Driving and driven-pulley speeds, rad/sec

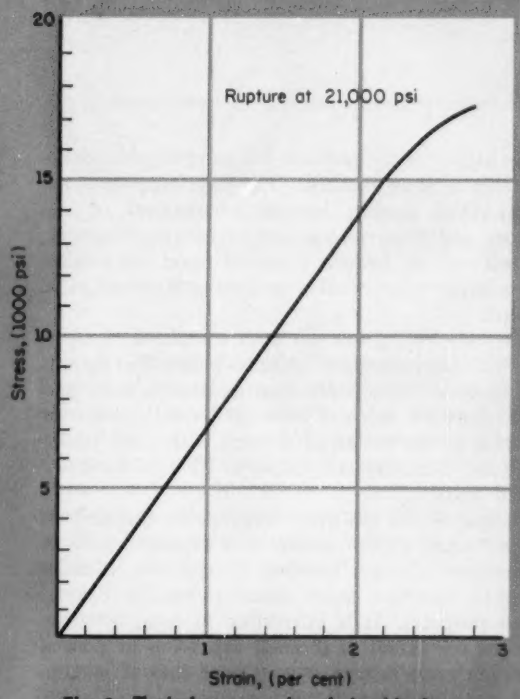


Fig. 2—Typical stress-strain relationship for a belt heat treated in a stretched condition at 250 F for one hour.

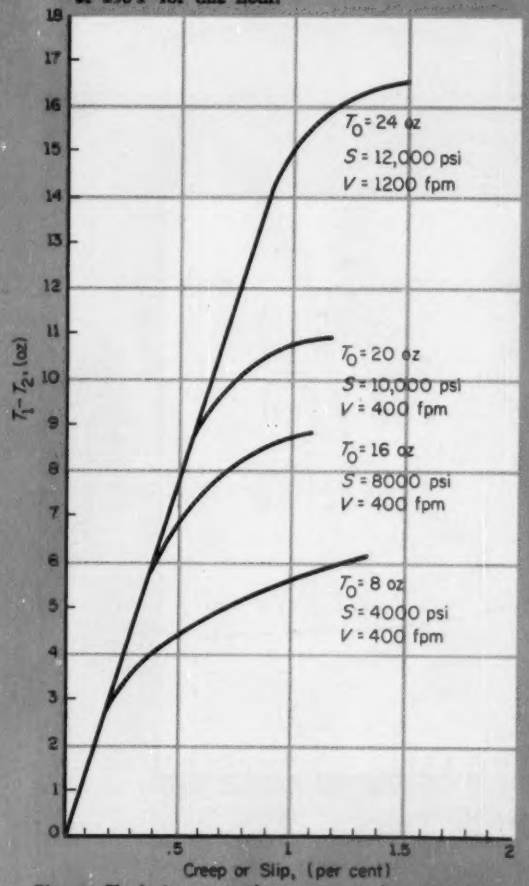

T_0 = 24 oz
S = 12,000 psi
V = 1200 fpm
T_0 = 20 oz
S = 10,000 psi
V = 400 fpm
T_0 = 16 oz
S = 8000 psi
V = 400 fpm
T_0 = 8 oz
S = 4000 psi
V = 400 fpm
$T_1 - T_2$, (oz)
Creep or Slip, (per cent)

Fig. 3—Typical curves of torque capacity versus creep: Polyester-film belts, 0.001-in. thick and ⅛-in. wide, over turned metal pulleys of ½-in. diameter.

$$T_1 + T_2 = 2T_0 \tag{5}$$

where T_1, T_2, T_0 are tight side, slack side, and initial tensions, respectively. The basic relation between the tight and slack-side tensions in terms of coefficient of friction μ and active arc β is

$$\frac{T_1}{T_2} = e^{\mu\beta} \tag{6}$$

which holds regardless of elastic characteristics when the centrifugal force is neglected.

Torque M and power in terms of T_0 and $e^{\mu\beta}$ are obtained from

$$M = 2T_0 r \left(\frac{e^{\mu\beta} - 1}{e^{\mu\beta} + 1} \right) \tag{7}$$

$$P = \frac{4\pi T_0 N r}{33{,}000} \left(\frac{e^{\mu\beta} - 1}{e^{\mu\beta} + 1} \right) \tag{8}$$

where T_0 is in pounds and r is in feet.

A number of tests have been made on the slip

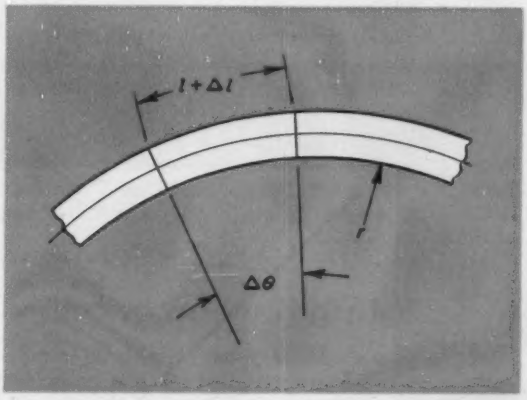


Fig. 4—Angle-arc relations during bending.

and creep characteristics of belts with variable torque to corroborate Equation 7 and to assign a value of μ. Because of variation in surface conditions and an apparent change in μ with speed, the test results were not completely consistent. However, a value of $\mu = 0.15$ for speeds below 4000 rpm and a value of $\mu = 0.2$ for speeds up to the point where centrifugal effects begin to appear is indicated for belts over turned metal shafts. Much higher values for specially coated shafts may be obtained. Typical performance curves based upon these tests are shown in Fig. 3. Belt creep is one-half to one per cent at relatively high torque levels.

To determine torque capacity, an allowable maximum stress, caused by initial tension, must be assigned. The method of applying initial tension

has a significant effect on the amount of initial tension which can be retained. No difficulty is experienced in compensating for elastic creep in applications where mechanisms are provided to maintain constant tension. In certain applications requiring extreme simplicity, however, or in applications subject to severe vibration and dynamic force, such as those produced by a guided missile, the use of constant tension mechanisms is not always desirable.

When the elasticity of polyester-film belts must retain the initial tension over pulleys at a fixed center distance, two counteracting effects must be considered. These effects are the "memory" of the plastic material which tends to increase initial tension, and the elastic creep which relieves this tension.

Heating at temperatures above that at which the belts are stretched, while the belts are in the stretched condition, relieves a large amount of this memory and also greatly increases yield strength. Heat-treatment at temperatures near 250 F significantly increases the torque capacity of the belts. Torque-capacity tests performed on heat-treated and nonheat-treated belts verified that the heat-treated belts of like thickness and width could withstand significantly higher initial preloads before noticeable yield-point limits were reached. The heat treatment reduces initial tension because of removal of the memory and thus reduces driving torque. However, the belt can be further stretched upon installation with a larger initial tension because of increased yield strength.

Adequate testing has not been completed to assess fully the creep-memory balance points for various conditions of belt stretch, heat-treatment, time, and temperature. A value of 2000 psi for T_0 seems conservative in the design of systems with fixed center distances. Tests indicate values to 5000 psi for heat-treated belts.

Because of the relatively large strain imposed on the belt cross section, differential expansion due to temperature change between it and the metallic structure does not merit consideration for normal design purposes. It is interesting to note, however, that the coefficient of thermal expansion at normal operating temperatures is very near that of magnesium and aluminum alloys.

Torque tests of adjustable center-distance systems have been made at initial stress levels of 8000 psi in

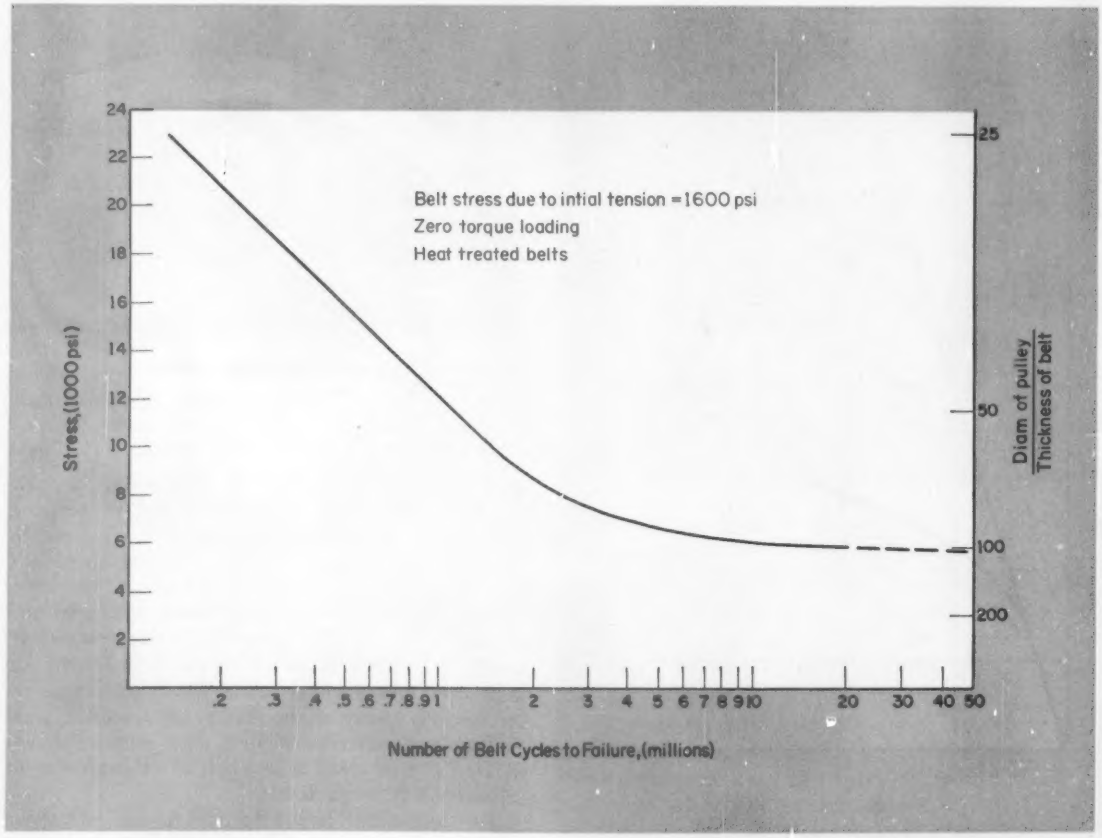


Fig. 5—Belt life as a function of bending stress, pulley diameter, and belt thickness.

tension, but life tests were not conducted on these systems. Nevertheless, a design value of 2000 psi, which is indicated for the fixed center distance, represents a large improvement over many belt systems.

Belt Life

It is obvious that simple tension forces in the straight section of a belt do not fully define its performance. Life, for example, is a property which cannot be correlated to constant tension. There is a complex stress distribution along the belt which includes a diminishing tension due to driving torque, bending over the pulley, and the initial tension. A bending stress relation can be derived. Consider a section of a belt over a pulley, Fig. 4.

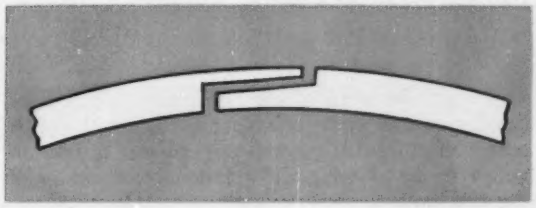


Fig. 6—The lap-joint splice.

From the geometry

$$l = \left(r + \frac{t}{2} \right) \Delta\theta$$

and

$$l + \Delta l = (r + t)\Delta\theta$$

But

$$S = \frac{E\Delta l}{l}$$

so that

$$S = E \left(\frac{t}{D + t} \right)$$

which reduces to

$$S = \frac{Et}{D} \qquad (9)$$

since t is small compared to D.

Failures after extended life of the belts seem to be similar to progressive fracture and have been correlated to the bending stress indicated in Equation 9. A number of life tests have been conducted on fixed-center pulley systems subject to an initial tension stress of approximately 1600 psi. The results suggest the relationship shown in Fig. 5, and can be used to determine minimum pulley diameters. For example, suppose the minimum pulley diameter is wanted for a belt ½-mil thick and a life of 1000 hr at 3000 rpm. Data from the curve lead to a minimum pulley diameter of 0.050 in. Further, suppose the belt system has a speed reduction of 10 to 1. The diameter of the larger pulley is 0.500 in. and the belt length can be found when the center distance is known.

Because size, and, indirectly, weight of a transmission system are established by the diameter of the smaller element, the foregoing example indicates that a more compact unit may be possible with a belt drive than with fine-pitch instrument gears.

Excellent high-speed characteristics are implied for the belts. If the rotating-ring analogy is used as a basis of estimating centrifugal force effects as in the conventional belt analysis, the limiting velocity is

$$v = \sqrt{\frac{Sg}{\gamma}} \qquad (10)$$

where S is limiting stress and γ/g is mass density. It is assumed then, that the ratio of limiting stress to density would be a fair measure of speed limitation of the belt.

For a density of the polyester film of 86 lb per cu ft and provisions for retensioning to allow a stress of 13,000 psi (2000 psi below that of the minimum measured elastic limit for a heat-treated belt), a theoretical limit of 47,000 fpm is calculated from Equation 10. The accomplishment of such a high speed is questioned for other reasons such as proper tracking. The highest speed the authors checked was 30,000 rpm on a ¼-in. diameter shaft.

Fabrication Techniques

Since the film is not available in tubular form, fabrication of these belts presents an unusual problem. An effort was made to produce reliable splices, but splices tended to negate the advantages of the thin cross section, high stress capacity, and invariant drive. Lap joints, Fig. 6, attained only 50 per cent of the tensile strength of the material and they varied in thickness.

Finally, stretching processes were employed to produce splice-free belts from flat sheet material, Fig. 1. Several stretching methods were tried, including stretching over two cylindrical rollers during the application of radiant heat. Stretching over cones produced belts of highest quality most rapidly, Fig. 7 to 10. Steps in fabrication of a belt are:

1. A flat ring with outside diameter approximately 5 per cent smaller than the finished belt diameter is cut from a flat sheet, Fig. 1.
2. The ring is placed over the ends of two cantilevered cones with cylindrical bases, Fig. 7. The distance and angle between the cone centerlines are adjustable and one cone is driven. The other cone is free to rotate on a bearing assembly.
3. The angle and distance between the cones are adjusted

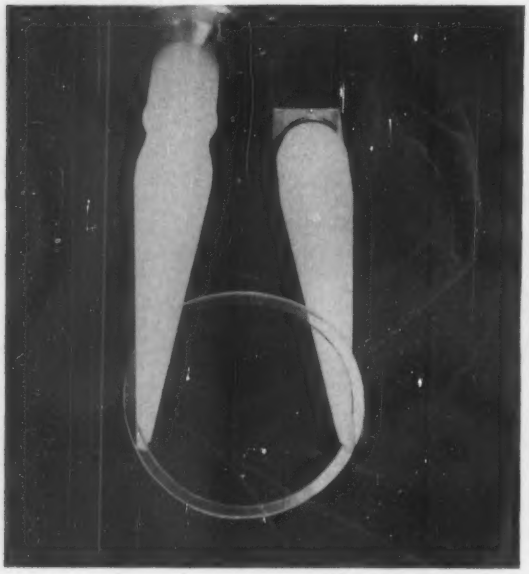


Fig. 7—Beginning of stretching operation.

Fig. 8—Stretching to length.

to produce a uniform advance to the cone base and the required belt length, Fig. 8.

4. The driven cone is rotated at a few revolutions per minute until the belt reaches the cylindrical portion of the tool, Fig. 9.
5. If all edge wrinkles are not stretched out of the belt or it is not to size the process is repeated, Fig. 10.

A milling machine can be conveniently adapted to the setup required. The angle between the cones is varied from 1 to 4 deg with 12-deg (included angle) cones. Increasing the angle between cones increases the rate of advance of the belt.

Wrinkled areas appear in a stretched belt because of nonuniform memory of the material. Memory is the property of plastic materials to recover original shape after distortion. The effects of memory can be greatly reduced by heat treating the belts during or after fabrication in the stretched condition at temperatures near 250 F.

Belts can be formed without difficulty from washers with minor diameter to outer diameter ratios to 0.7. This ratio establishes the stress that must be put on the inside radius of the washer to stretch it into a belt. Theoretically, the limit is established by the strain of the material in per cent at break.

Mylar properties are such that a possible ratio of 0.5 is indicated. Belts have been formed for ratios less than 0.7, but the mortality rate has been high.

Care must be exercised during the stretching process to avoid undesirable lateral wandering of the belt centerline. The belt should be trimmed on both edges to eliminate cross section wander.

Obviously the differential stretching produces a wedge-shaped cross section. Variation of this wedge is a function of the inner and outer radii of the initial washer. The wedge section has the effect of causing the belt to track off center on a crowned pulley. This characteristic, although of little consequence other than to increase pulley width, may be compensated for by providing a crown with radius center offset from the lateral centerline of the driven pulley or by skewing the rotational centerlines of the two pulleys.

Crowned pulleys have been used almost exclusively because of reliable tracking. The crown required on the driven pulley (in standard practice the driving pulley is not crowned) is a function of pulley diameter, belt width and thickness, misalignment of pulley centerlines, initial tension in the belt, speed, and other factors. However, a crown radius of 2.5 in. has generally proved satisfactory.

Polyester-film material has high dielectric strength and surface resistivity. The advantages and effects of static electrical charges have not been fully explored. However, in one case, this charge has been utilized to retain a belt in position and to restrain it from rubbing the driving pulley when the belt was declutched by an idler pulley, Fig. 11. The charge required to accomplish this retention is developed from the simple initial rubbing of the belt against a magnesium driving pulley.

Temperature is another environmental factor to which the polyester-film belts have an exceptional tolerance. This tolerance results not only from the relatively high-temperature strength of the material, but also from low internal friction in flexing over the pulley and low external friction resulting from reduced creep across the surfaces of the pulley. Published data indicate that the polyester film retains useful properties to 150 C. The belts are also resistant to chemicals, solvents, and radiation.

Applications

Miniature drives are distinct possibilities—½-mil belts can be applied to shafts as small as 0.040-in.

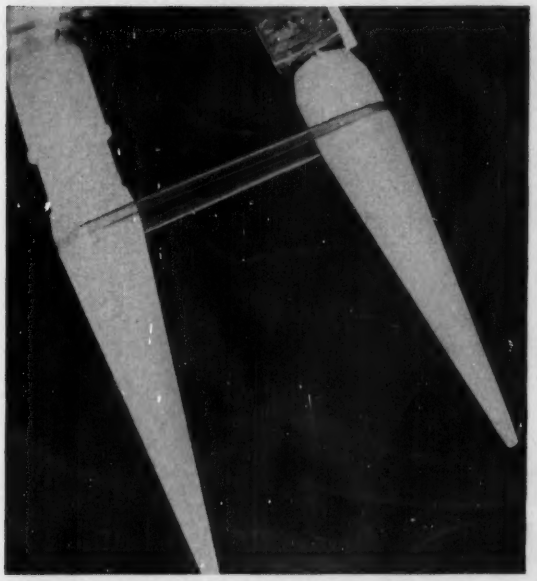


Fig. 9—Finish stretching operation.

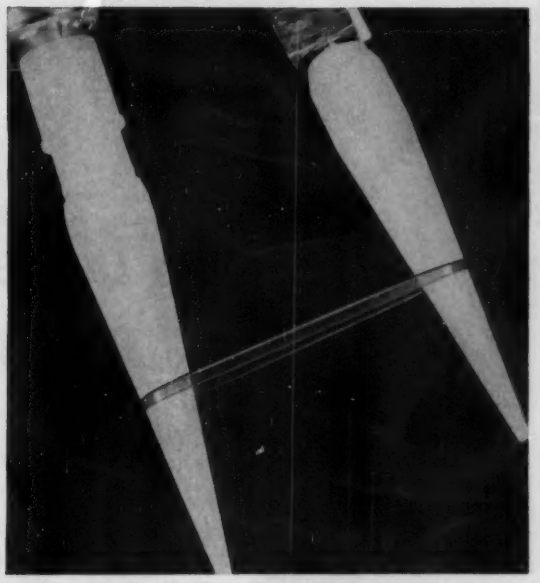


Fig. 10—Restretching and wrinkle-ironing operation.

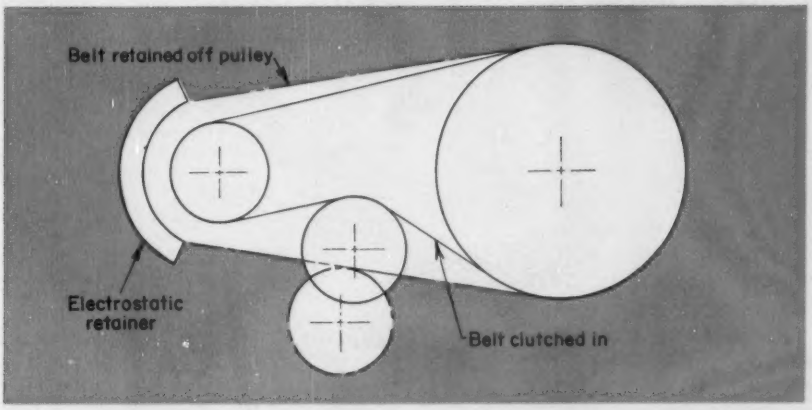


Fig. 11 — Static clutch system.

diameter with reasonable life. Application can be made to even smaller shaft diameters, but torque will be limited. It has been estimated that a 1000:1 speed reduction could be accomplished in a ½-inch cube.

Successful applications were made in the recorder in the Vanguard II satellite launched in February, 1959, the Atlas talking satellite launched in December, 1958, and a more sophisticated time-compression recorder of the Vanguard II type to be used in a later Tiros satellite. Use in the recorders in Tiros I, launched on April 1, 1960, provided large reductions in flutter and power loss over a former fixed-center friction drive. The range of belt sizes in these applications is from a 1/16-in. wide belt of ½-mil thickness to a 5/16-in. wide belt of 1-mil thickness.

In addition, the belts have been used in assorted laboratory test devices and machine-shop fabrication set-ups. In one case, a 5-mil belt was substituted for a fabric and rubber belt on a 1/12-hp, 22,500-rpm grinder with excellent results.

Certain servo applications requiring zero backlash but not perfect registration have been studied to determine if they might benefit from the fluctuation-free drive characteristics. A reduction of 3600 to 1 was fitted to a servo motor synchro combination. Immeasurable backlash was demonstrated with the aid of a cross hair reflected from a mirror mounted on the low-speed shaft.

Thought has been given to the application of polyester-film belts to power drives. For example, consider a belt for a 10-hp motor at 3000 rpm. Assume a rubber-coated drive pulley of 2-in. diameter, a coefficient of friction of 0.4, an initial tension of 7000 psi, and a contact angle of 3 radians. A 10-mil belt would be about 3-in. wide.

ACKNOWLEDGMENT

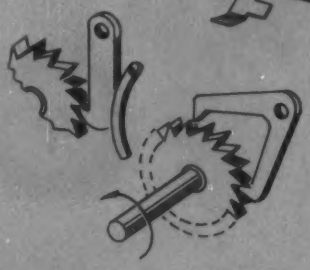
The process of stretching the belts over cones, as described here, was developed by Mr. John Kwik, a machinist at the Signal Corps Laboratories where the authors started work on the belts.

11 Stop Devices

for Control-Shaft Positioning

FRANK W. WOOD JR.
Advanced Designs Inc., Vienna, Va.

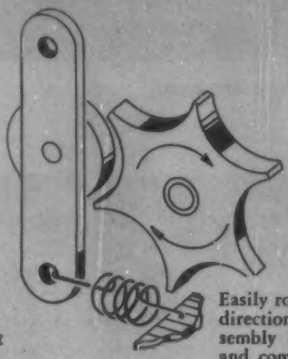
Delicate angular adjustment, but can be turned wrong way.



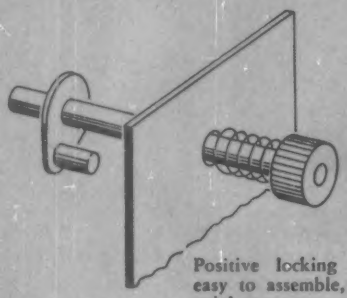
Locks positively with little slip; arm positioning is complicated.

Rugged one-way stop, but complex to install.

Smooth rotation, but complex to install.

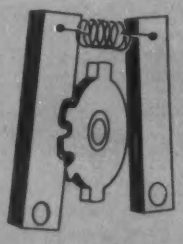


Easily rotated in either direction; however, assembly is often large and complex.



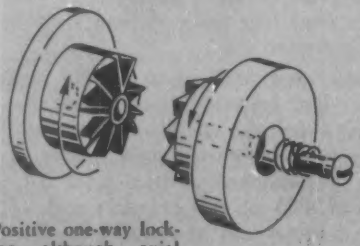
Positive locking and easy to assemble, but axial movement must precede rotation.

Rotation in either direction, but assembly is complicated.

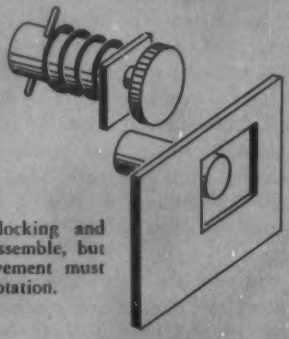


Rotation in either direction to stops, though stops are not always reliable.

Rotation in either direction, but difficult to turn to position.



Positive one-way locking although axial movement is necessary to release.



Positive locking and easy to assemble, but axial movement must precede rotation.

A new method for

Designing Cams for Analog Computers

Charts are presented here for the design of cam mechanisms to match either a known function or empirical data. The charts permit the selection of a ratio of center distance to follower-arm length, and define the corresponding range of pressure angles. Follower-roller diameter can be selected to avoid undercutting, other dimensions can be proportioned, and pressure angles at the beginning and end of cam rise can be adjusted for optimum conditions.

CHARLES EUMURIAN
Principal Engineer
Mechanical Div.
General Mills Inc.
Minneapolis, Minn.

Nomenclature

- A = Cam input scale factor, units of input per deg of cam rotation
- B = Cam output scale factor, units of output per deg of follower arm rotation
- b = Center distance from cam center to follower-arm pivot point
- h = Length of cam-follower arm
- k = Size ratio
  $= b/h$
- p = Pressure angle relative to follower-arm centerline
- R = Radius of curvature of locus of centers of follower-roller center
- r = Radius of cam-follower roller
- x = Reference horizontal co-ordinate
- y = Reference vertical co-ordinate
- Γ = Angle between radius and horizontal reference
- η = Angle between tangent to locus of centers curve and normal to radius
- θ = Cam output angle (rotation of follower arm)
- ρ = Radius from cam center to center of follower roller
- τ = Angle between horizontal reference and tangent to locus of centers curve
- ϕ = Cam input angle (rotation of cam)
- ψ = Angle between radius and line joining centers of cam and follower arm
- ω_i = Cam angular velocity (positive for clockwise rotation)
- ω_o = Follower arm angular velocity (positive for clockwise rotation)

IN THE design of electromechanical analog computers, functions must often be generated from given input parameters. The selection of an appropriate function generator depends upon the accuracy requirements, torque limitation on the input shaft, range of the variables, and space limitation in the computer.

There are several methods by which functions can be generated. One of them is the use of a cam-and-follower mechanism.[1] A properly designed cam provides great accuracy while being rugged and reliable. Practically no limit exists on the type of functions which can be synthesized. This analysis provides means by which the parameters of a cam for computers can be selected during design.

The Problem: Two types of cams are possible: Cams with pivoted or swinging-arm followers and cams with straight-line-motion followers. In each of these types, the following cam parameters must be considered in the design:

1. Pressure angle.
2. Cam size.
3. Ratio of follower-arm length to the distance between the cam and follower centers for the pivoted-follower types. This ratio is called the size ratio.
4. Offset distance between the cam center and the line of motion for followers constrained to straight-line motion.

[1]References are tabulated at end of article.

5. Cam curvature.
6. Follower roller radius.
7. Follower arm initial position.

Since these parameters are interrelated, the designer must juggle them on the basis of the required function to come up with a satisfactory design. The type of function and the range in value of the input variable are the predominating factors. Only roller-type followers are considered here since analog computers generally require a minimum of friction in each component.[2] The analysis is applied to the pivoted follower-arm cam with rotary output because rotating elements are used extensively in electromechanical computers.

To start with, all that is known about the problem is the function relating the output to the input. A general solution for all possible functions within the intrinsic cam limitations is attainable. It can be shown that a unique output function is obtained when one parameter is held constant, making it possible to set up a family of curves of cam parameters which will set bounds upon the problem.

The problem basically is to determine what values of roller diameter, center distance, follower-arm length and initial output position should be chosen in order to have a range of pressure angles commensurate with the force considerations in the system.

Cam Pressure Angle: If the pressure angle were to remain constant, the cam and follower motion would be defined. The stipulation that the pressure angle remain constant becomes itself a forcing function for the motion. This analysis therefore is basically a study of cams with constant pressure angles. These constant pressure angle cams are the tools by which any computer cam can be designed.

To describe the position of the elements of the cam mechanism, the cam is fixed and the follower-arm center moved around the cam. Input angle ϕ, which is the rotation of the cam, may be considered to be the rotation of the follower-arm center around the cam center in a counterclockwise direction, Fig. 1. Output angle θ, is measured from the line joining the cam center and the follower center.

The parametric equations in rectangular co-ordinates for the locus of the follower roller center from Fig. 1 are

$$x = b \cos \phi - h \cos (\theta - \phi) \quad (1)$$

$$y = b \sin \phi + h \sin (\theta - \phi) \quad (2)$$

Slope τ of the follower center locus is defined by

$$\tan \tau = \frac{dy}{dx} = \frac{\frac{dy}{d\phi}}{\frac{dx}{d\phi}} \quad (3)$$

From triangle *ABC*, Fig. 1, pressure angle p is re-

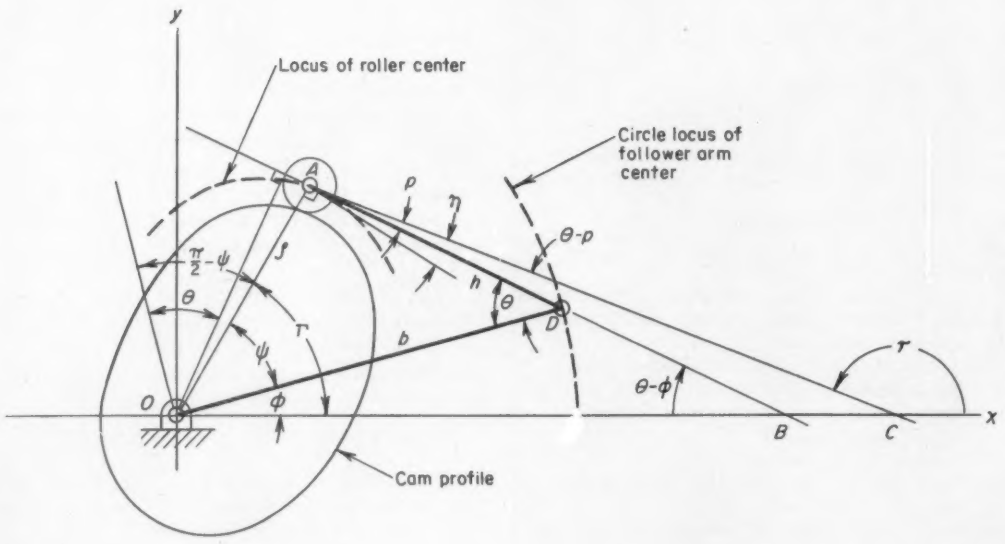


Fig. 1—Geometry of a cam mechanism having a pivoted roller follower.

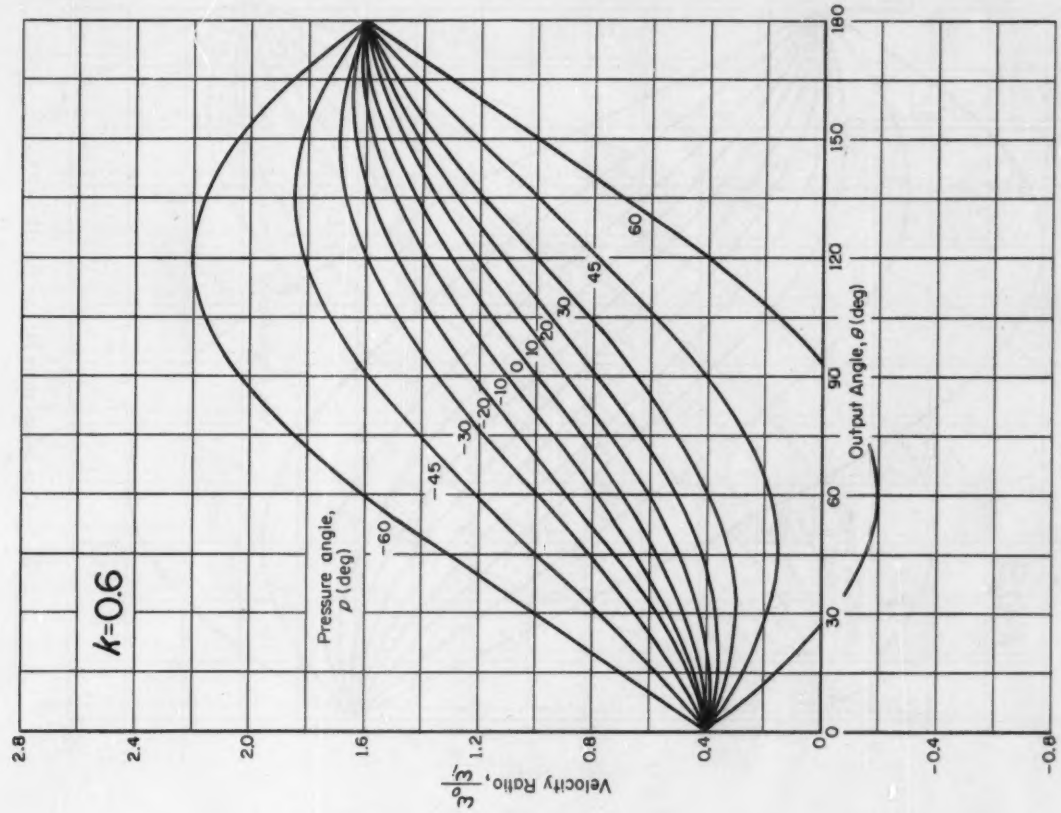


Fig. 3—Cam design chart for size ratio, k = 0.6.

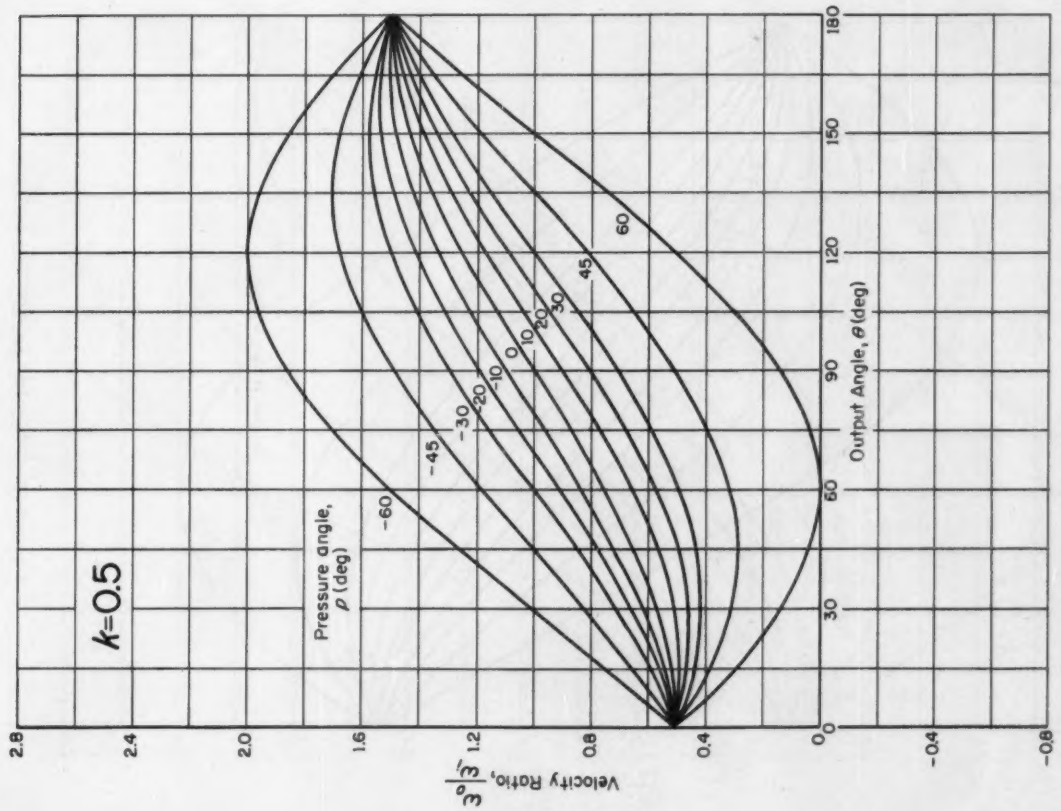


Fig. 2—Cam design chart for size ratio, k = 0.5.

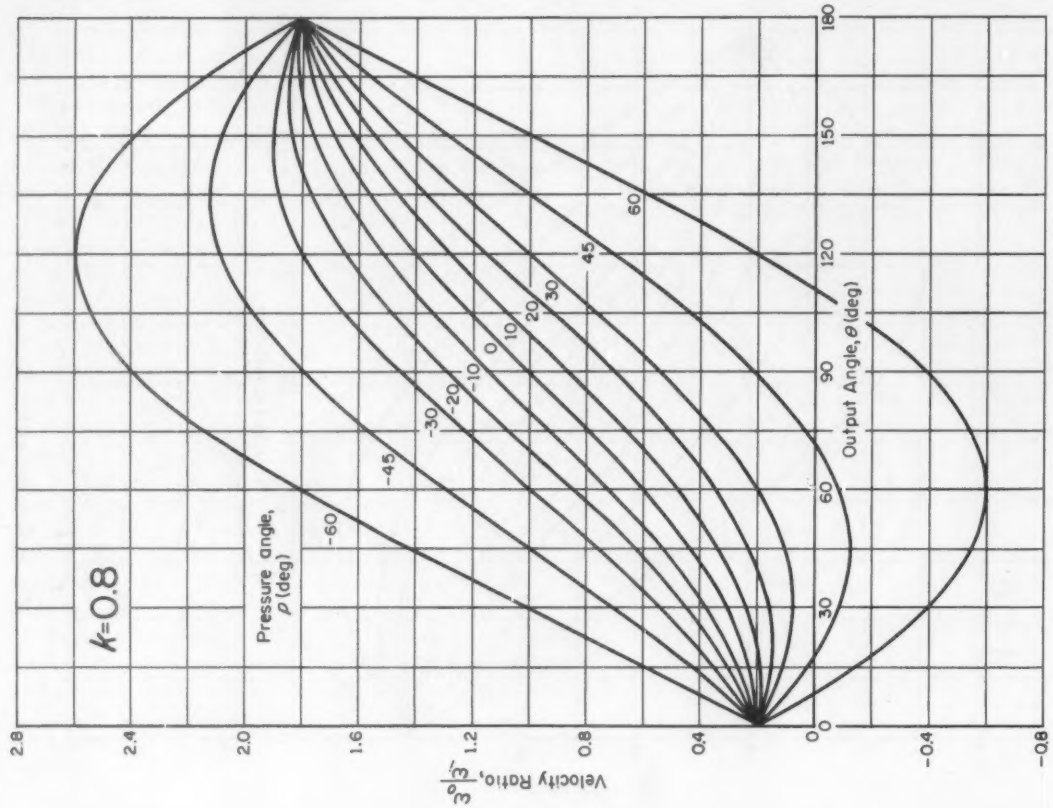


Fig. 5—Cam design chart for size ratio, k = 0.8.

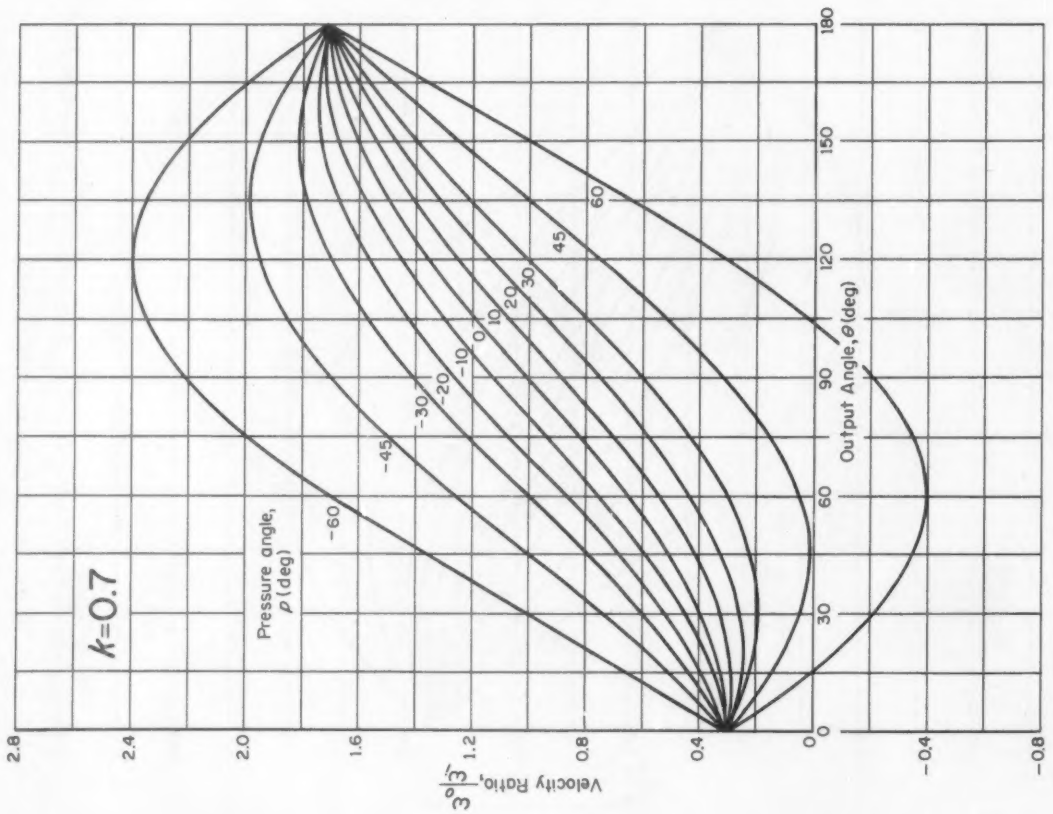


Fig. 4—Cam design chart for size ratio, k = 0.7.

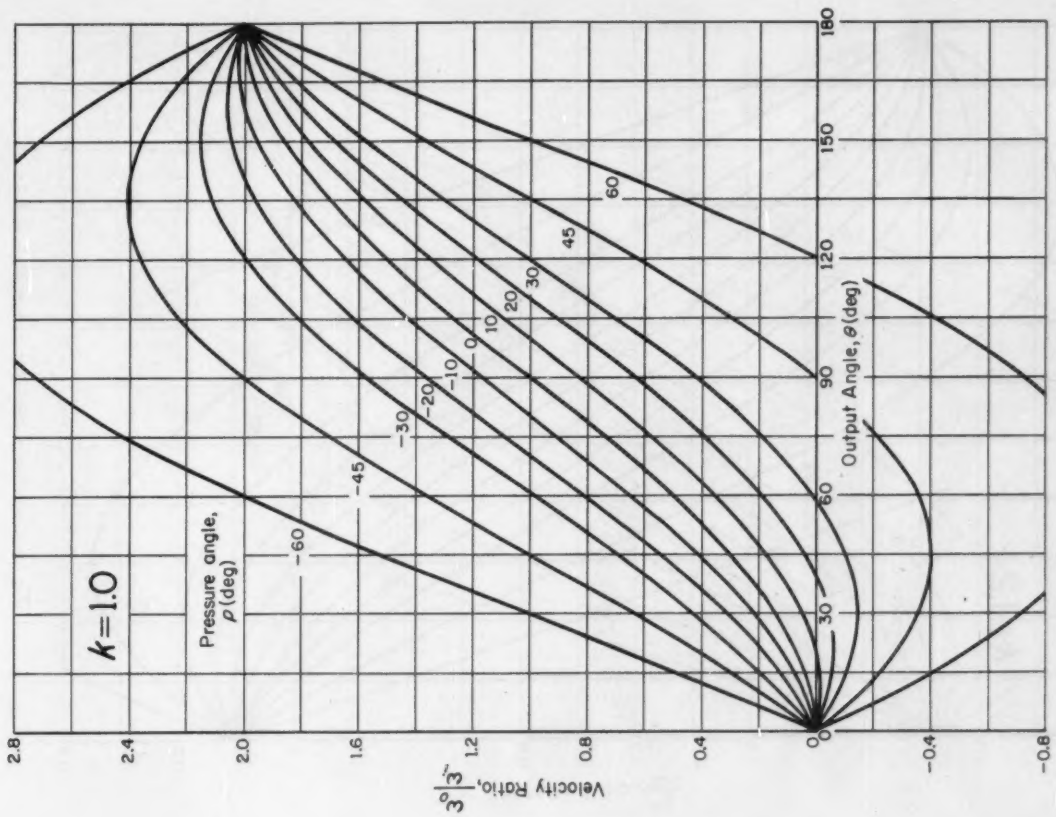


Fig. 7—Cam design chart for size ratio, k = 1.0.

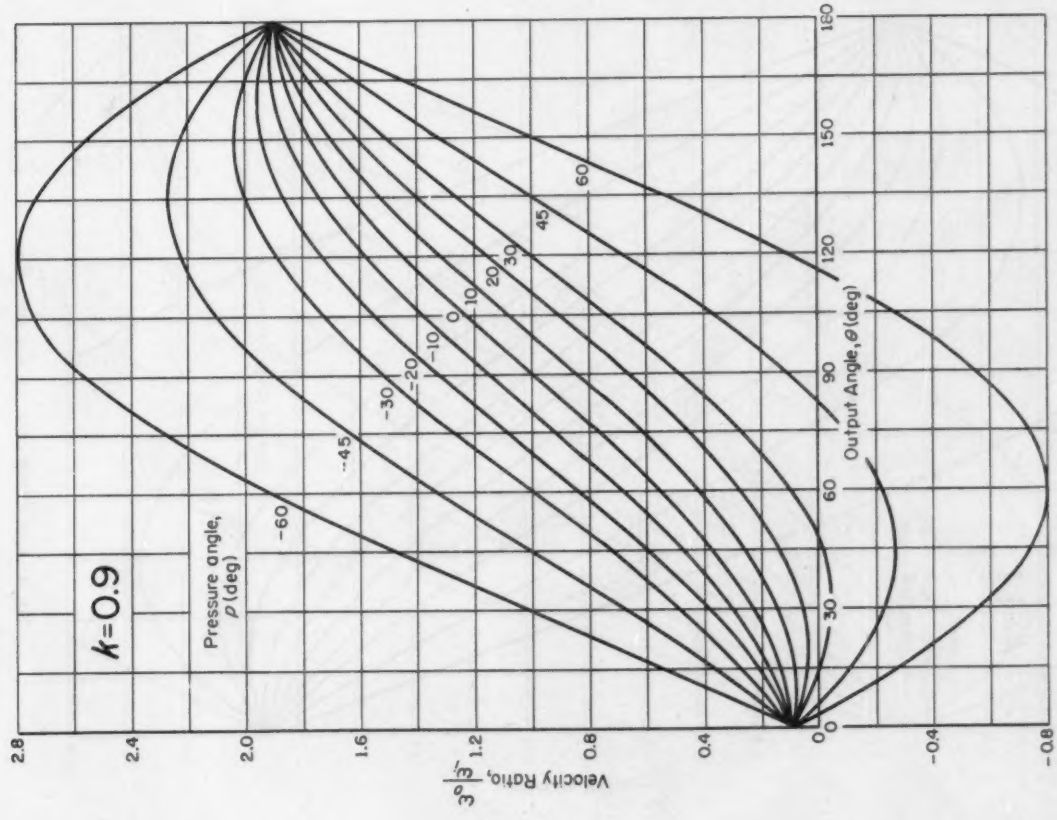


Fig. 6—Cam design chart for size ratio, k = 0.9.

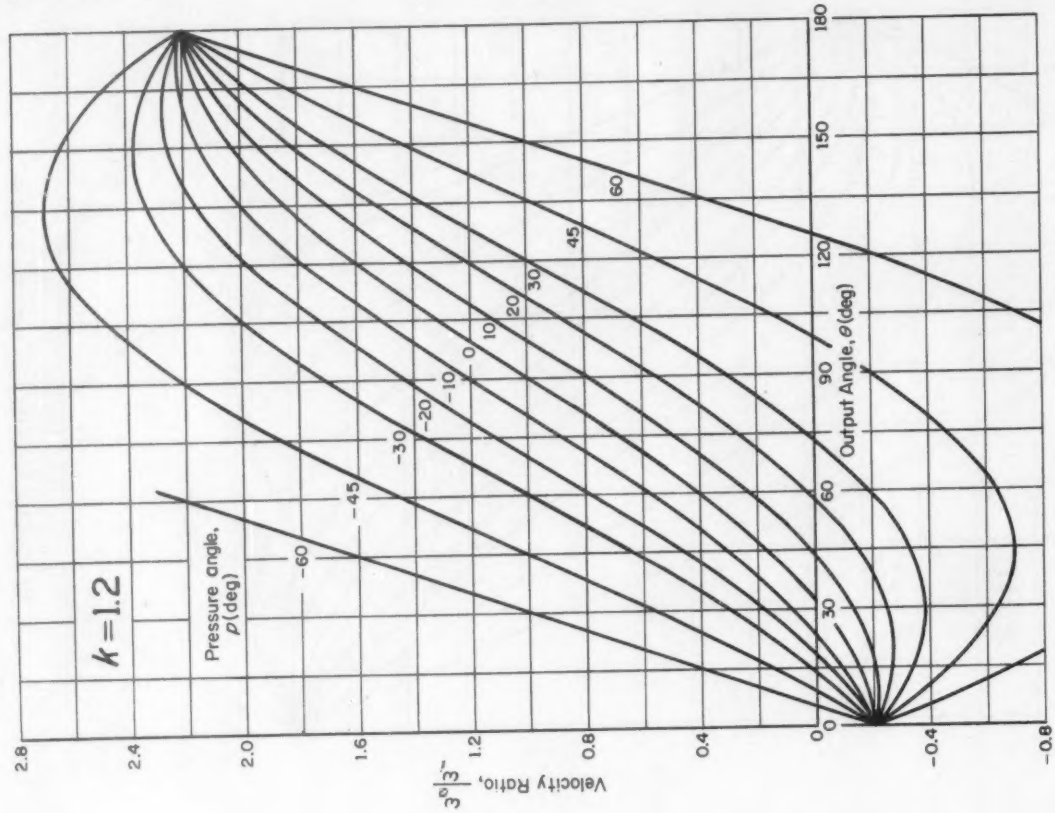


Fig. 9—Cam design chart for size ratio, k = 1.2.

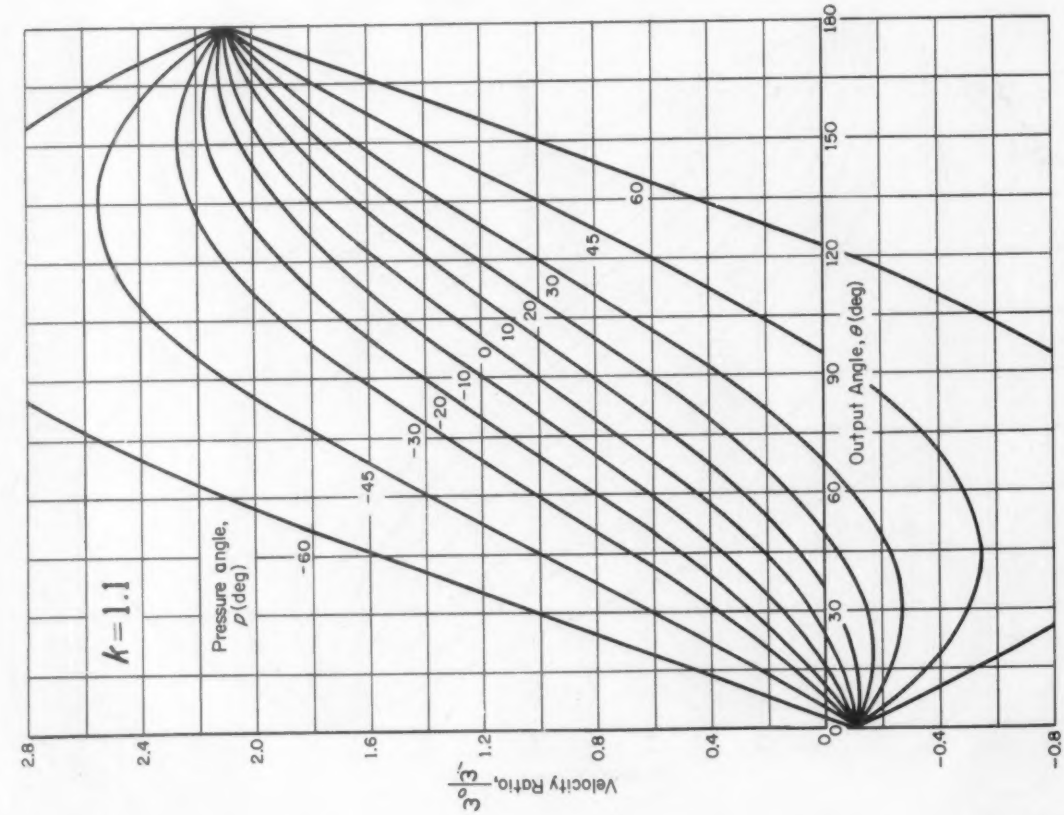


Fig. 8—Cam design chart for size ratio, k = 1.1.

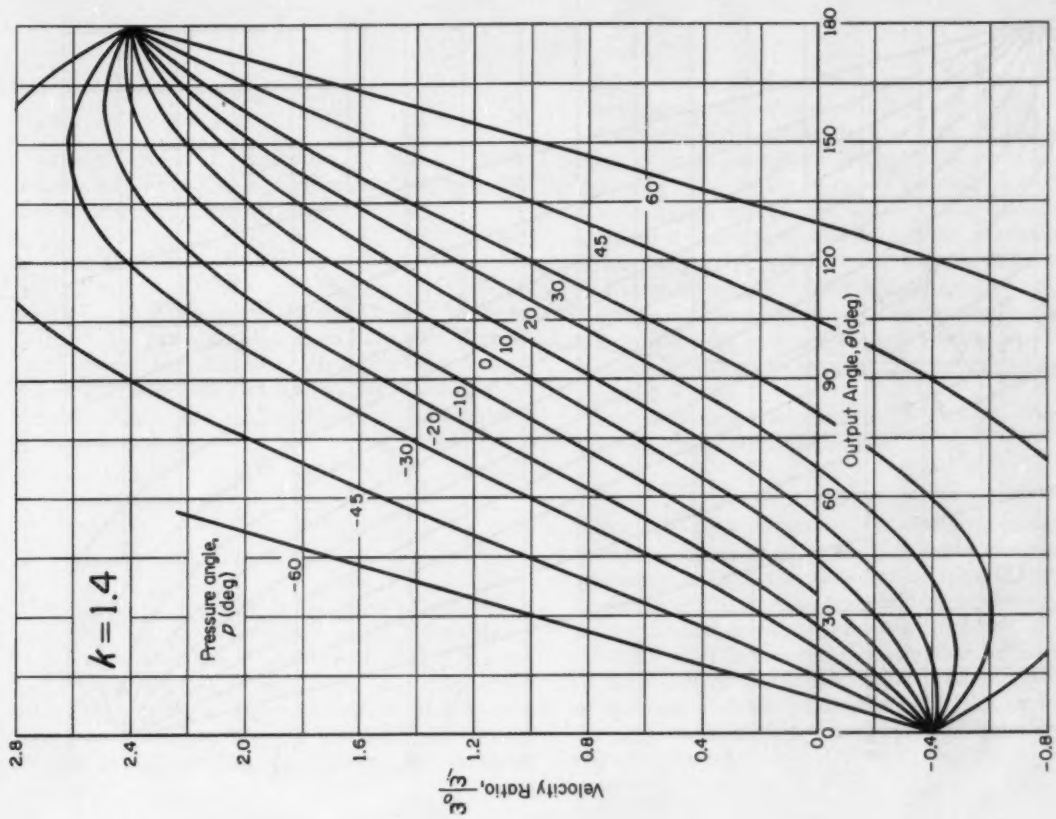


Fig. 11—Cam design chart for size ratio, k = 1.4.

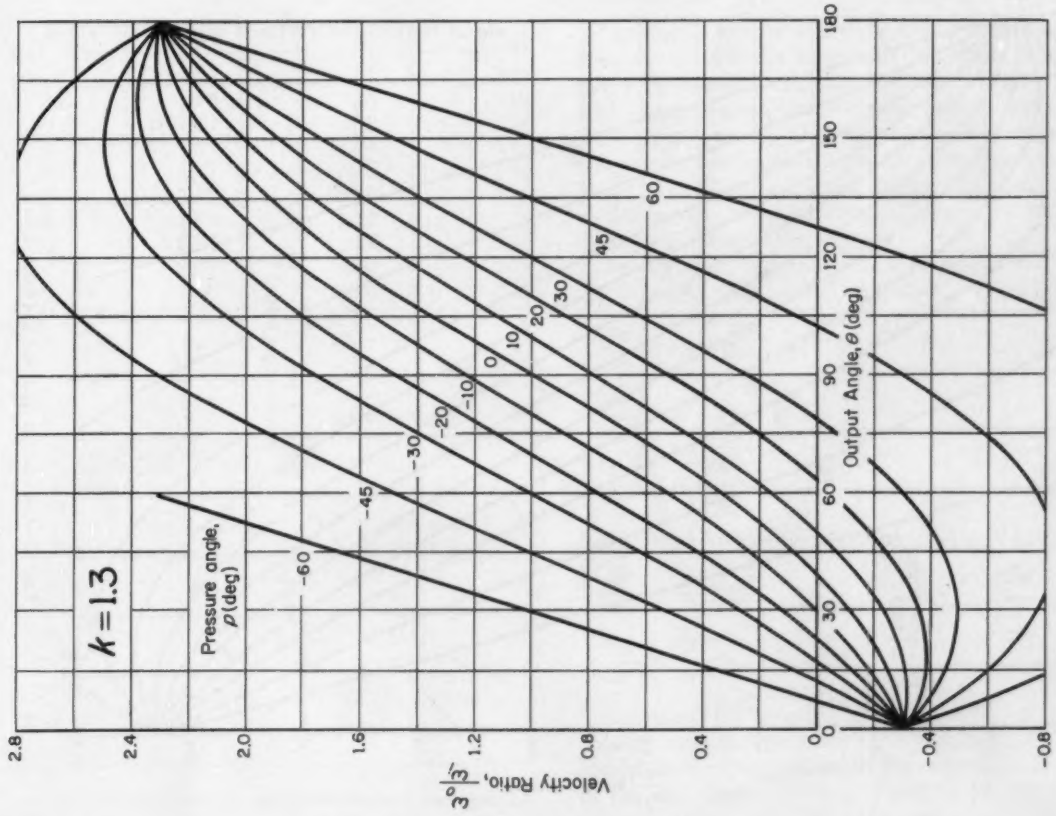


Fig. 10—Cam design chart for size ratio, k = 1.3.

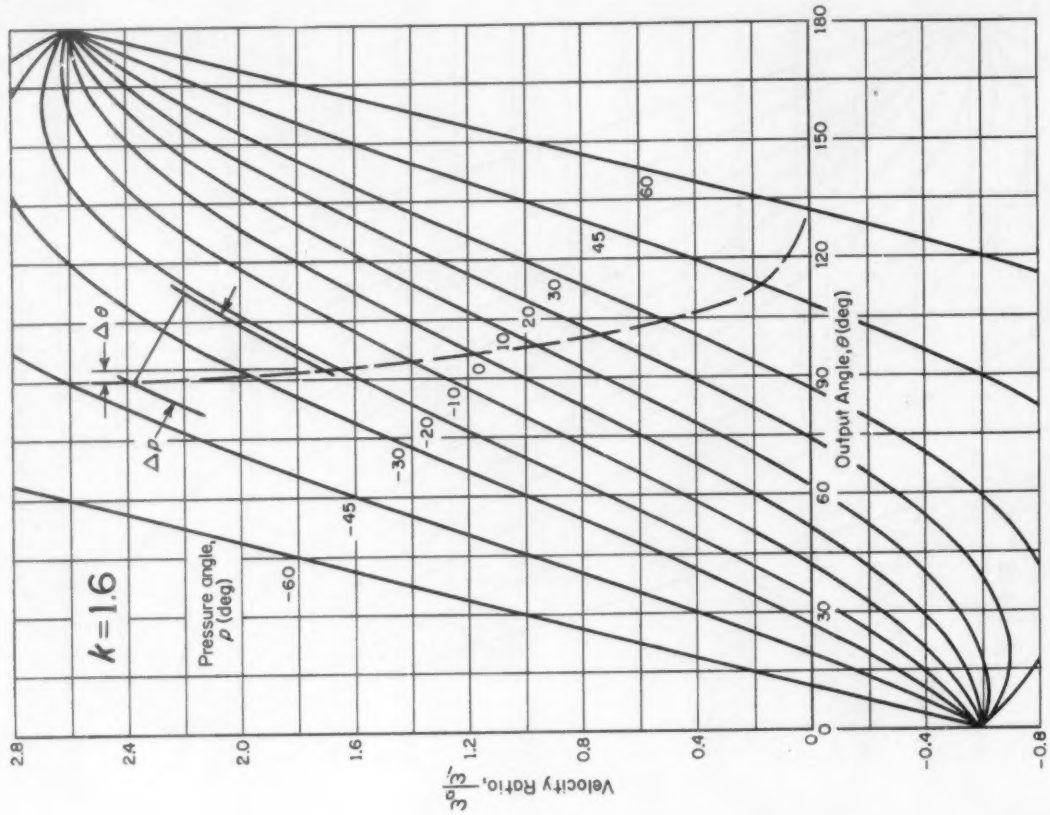


Fig. 13—Cam design chart for size ratio, k = 1.6.

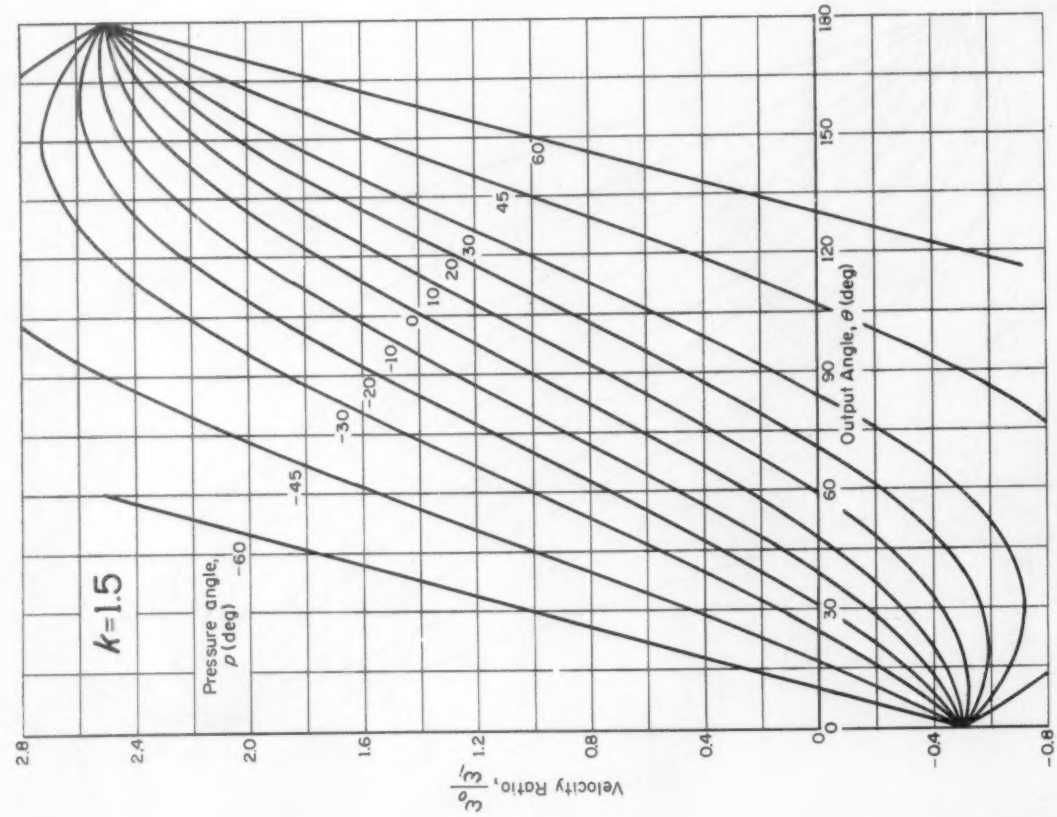


Fig. 12—Cam design chart for size ratio, k = 1.5.

lated to the other angles by

$$p = \tau - \pi + (\theta - \phi) \tag{4}$$

Differentiations of Equations 1 and 2, substitutions into Equation 3 to eliminate slope τ, and rearrangement of the terms gives

$$\frac{d\theta}{d\phi} = 1 - \frac{k \cos(\theta - p)}{\cos p} \tag{5}$$

where $k = b/h$, the size ratio of the cam mechanism.

Up to this point, no limitations have been imposed upon the problem. Equation 5 is a general expression which indicates that a functional relationship exists between $d\theta/d\phi$, k, θ, and p. The dependent variable of Equation 5 is

$$\frac{d\theta}{d\phi} = \frac{\dfrac{d\theta}{dt}}{\dfrac{d\phi}{dt}} = \frac{\omega_o}{\omega_i} \tag{6}$$

This dependent variable is the ratio of the output velocity of the cam follower arm to the input velocity of the cam. Equation 5 also reveals that if the velocity ratio is to be a function of only the output angle, both pressure angle and ratio k must be held constant. Pressure angle and size ratio can be considered as independent parameters. By assigning varying values to these parameters, families of cam curves, or charts, can be drawn.

Table 1—Velocity Ratio Versus Output Angle

x	y	$\theta - \theta_o$	ω_o/ω_i
10	1.000	0.0	2.38
20	1.301	6.02	1.19
30	1.477	9.54	0.79
50	1.701	14.02	0.48
100	2.000	20.00	0.24
200	2.301	26.02	0.12
300	2.477	29.54	0.08
500	2.701	34.02	0.05
1000	3.000	40.00	0.02

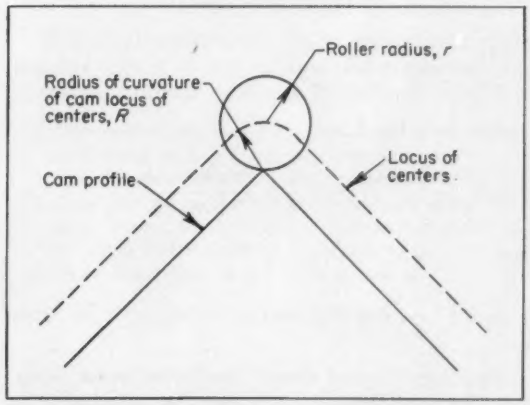


Fig. 14—Condition for minimum radius of curvature.

Such charts are shown in Fig. 2 to 13, inclusive. Each chart is plotted for a specific value of k, the size ratio. The family of curves on each plot shows various values of pressure angle. Thus, the charts show how velocity ratio varies with the follower output angle, when the cam geometry (ratio k and pressure angle) is held constant.

Of course, a cam which has constant pressure angle is not called for in practical applications. But these families of curves can be used to assist in the design of practical cams.

Let the function which is to be synthesized in an electromechanical computer be

$$y = f(x) \tag{7}$$

where x is the input and y is the output. Scale factors must be assigned to each variable in order to relate the units of the variables to units of rotation of the mechanism. The scale factors might already be established conditions for the problem. If not, arbitrary scale factors can be calculated on the basis of the range of the variables and maximum motion of the cam and the follower arm. These equations for scale factors relate the theoretical variables to the cam system:

$$x - x_o = A\phi \tag{8}$$

$$y - y_o = (\theta - \theta_o)B \tag{9}$$

Nothing is lost by assuming that ϕ is zero when x equals x_o. A is the input scale factor and B is the output scale factor. The objective now in view is to find the expression for the cam velocity ratio for the desired function. Once this has been determined, comparison can be made with the cam-design charts of Fig. 2 to 13 to find a cam family which will have a satisfactory range of pressure angles to accommodate the required motion.

To find the expression for the velocity ratio for the function, differentiate Equations 7, 8, and 9.

$$\frac{dy}{dx} = f'(x) \tag{10}$$

$$\frac{dx}{d\phi} = A \tag{11}$$

$$\frac{dy}{d\phi} = B\frac{d\theta}{d\phi} \tag{12}$$

Substitution of Equations 11 and 12 into 10 produces

$$\frac{d\theta}{d\phi} = \frac{A}{B} f'(x) \tag{13}$$

$$\frac{\omega_o}{\omega_i} = \frac{A}{B} f'(x) \tag{14}$$

Equations 13, 9, and 7 can be used to plot the velocity ratio as a function of output angle θ. This should be done on vellum to the same scale as that of the cam design charts in Fig. 2 to 13. By over-

laying the vellum on the design curves, a cam design is found which has an appropriate range of pressure angle. The initial output angle is also determined from the design charts. A point to be remembered is that the mechanical initial angle θ_o need not be identical with the mathematical angle θ_o as given in Equation 9. However, the range of variation of the cam output angle θ must coincide with variation in the angle as required by Equation 9.

An example at this point will clarify the discussion. Assume that a cam is required to synthesize the function,

$$y = \log_{10} x \tag{15}$$

where x ranges from 10 to 1000. The corresponding range of y is from 1 to 3. Assume the full range of x causes one revolution of the cam and that the output range has an arc of 40 deg. The scale factor for the cam input can be determined from Equation 8. That is, $1000 - 10 = A$ (360 deg), or $A = 2.75$ units per deg. The cam output scale factor can be calculated from Equation 9 : $3 - 1 = B$ (40 deg), or $B = 0.05$ unit per deg.

Equation 14 for the specified function becomes

$$\frac{\omega_o}{\omega_i} = \frac{A}{B}\,\frac{d}{dx}\,(\log_{10} x) = \frac{A}{B}\,\frac{(0.43429)}{x} \tag{16}$$

Substitution of the scale factors into Equation 16 gives

$$\frac{\omega_o}{\omega_i} = \frac{23.886}{x} \tag{17}$$

From Equations 15, 9, and 17 and the foregoing scale factors, Table 1 is composed. It gives the velocity ratio of the required input function in terms of output angle θ.

The data from Table 1 are shown plotted as a curve on the cam design chart of Fig. 13. From this curve, the range of pressure angle can be seen to be from -40 to $+59$ deg, with an initial output angle of 90 deg. If the initial output angle is increased, the pressure angle at the start of the motion where high output velocity exists can be reduced. This in turn will increase the pressure angle at the other end of the motion where the effect is less serious. The output velocity is low near the end of the motion.

Superposition of the desired output curve on any other cam design chart results in much larger pressure angles at the extremities of the cam motion. Size ratio k for a workable cam design is thus found to be 1.60.

To complete the design of the cam mechanism, the radius of the cam-follower roller must be found and a value selected for the center distance. These parameters cannot be selected until an analysis of the cam radius of curvature is made.

Cam Radius of Curvature: To make the locus of the centers of the roller coincide with the desired analytical curve, the radius of the roller must not exceed the minimum radius of curvature of the analytical curve. This condition is illustrated in Fig. 14.

If the roller radius is larger than the radius of curvature of the locus of centers, the condition known as "undercutting" will result.[3] The locus of centers will "round off" the desired analytical curve if the roller is too large. Thus an analysis of the radius of curvature is necessary in order to select a suitable size of follower roller.

The radius of curvature of a plane curve is expressed in polar co-ordinates[4] by

$$R = \frac{\left[\rho^2 + \left(\frac{d\rho}{d\Gamma}\right)^2\right]^{3/2}}{\rho^2 - \rho\,\frac{d^2\rho}{d\Gamma} + 2\left(\frac{d\rho}{d\Gamma}\right)^2} \tag{18}$$

where R is the radius of curvature, ρ is the radial co-ordinate of the curve, and Γ is the angular co-ordinate of the curve. The curve being considered is the locus of centers of the cam follower roller, Fig. 1.

The slope of the tangent to the curve with respect to the radius at the point of tangency is

$$\tan \eta = \frac{d\rho}{\rho\, d\Gamma} \tag{19}$$

The slope is zero when the tangent to the curve is normal to the cam radius at the point of tangency. When the derivatives of Equation 19 are put into Equation 18,

$$R = \frac{\rho}{\left(1 + \frac{d\eta}{d\Gamma}\right)\cos \eta} \tag{20}$$

By summing the interior angles of triangle AOD, Fig. 1,

$$\eta = p - (\theta + \psi) + \frac{\pi}{2} \tag{21}$$

Differentiation of Equation 21 gives

$$\frac{d\eta}{d\Gamma} = \frac{dp}{d\Gamma} - \frac{d(\theta + \psi)}{d\Gamma} \tag{22}$$

Also from Fig. 1,

$$\tan\left[\frac{\pi}{2} - (\theta + \psi)\right] = \frac{b\cos\theta - h}{b\sin\theta} \tag{23}$$

and

$$\rho\cos\left(\frac{\pi}{2} - \psi\right) = h\sin\theta \tag{24}$$

Equations 24 and 5 and the derivative of Equation 23 with respect to ρ can be substituted in Equations 22 and 20 to obtain

$$\frac{R}{b} = \frac{\sin\theta}{\cos p\left[1 + \frac{d\theta}{d\phi}\left(\frac{dp}{d\theta} - 1\right)\right]} \qquad (25)$$

Equation 25 in conjunction with data taken from a pertinent cam design chart indicates the points where the radius of curvature is a minimum. Radius of curvature should be computed at several points along the curve of velocity ratio. Quantity $dp/d\theta$ can be approximated with $\Delta p/\Delta\theta$ along the velocity-ratio curve. If the velocity-ratio curve is located on a cam design chart such that the pressure angle is large near the extremities of the motion, then the minimum values of the radius of curvature will probably lie at the extremities of the cam motion.

If the radius of curvature is found to be too small at some point to permit a roller follower of practical size, it may be necessary to find a design from a different cam design chart—one that will tend to decrease the pressure angle at the end points of the cam motion. The same effect can be produced by changing the scale factors on the input and output of the cam; however, these parameters are sometimes fixed and not subject to further variation.

Again, an example will clarify the procedure. Consider the previous example where the function $y = \log x$ is synthesized. From the curve as shown on Fig. 13, the values of R/b can be calculated at the extremities of the motion. At the starting point of the motion, $\theta = \theta_o = 90$ deg, $p = -40$ deg, $\omega_o/\omega_i = 2.38$, and $\Delta p/\Delta\theta = 18/3 = 6.00$. Then

$$\frac{R}{b} = \frac{\sin 90}{\cos(-40)[1 + 2.38(6.00 - 1)]}$$

$$= 0.101$$

At the end of the motion, $\theta = 130$ deg, $p = 59$ deg, $\omega_o/\omega_i = 0.0238$, and $\Delta p/\Delta\theta = 4/6 = 0.67$. Then

$$\frac{R}{b} = \frac{\sin 130}{\cos 59[1 + 0.0238(0.67 - 1)]}$$

$$= 1.49$$

The smallest value of R/b appears at the start of the motion. Calculation of R/b at intermediate points may be necessary in some problems. The value of ratio r/b where r is the roller radius must be less than R/b. Thus, if r is assumed to be 1/8 in. (1/4-in. diameter roller), then b, the cam center distance, must be larger than 0.125/0.101 or 1.260 inches. The designer is now free to select values for r, b, and h, knowing that $b/h = 1.60$ and that r/b must be less than 0.101.

The problem is thus solved and the following is a solution which fits the limits established: $r = 0.125$ in., $b = 1.600$ in., $h = 1.000$ in., $\theta_o = 90$ deg, $p_{min} = -40$ deg, and $p_{max} = +59$ deg.

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4. L. S. Marks—*Mechanical Engineers' Handbook,* McGraw Hill Book Co., N. Y., Fourth Edition, p. 164.

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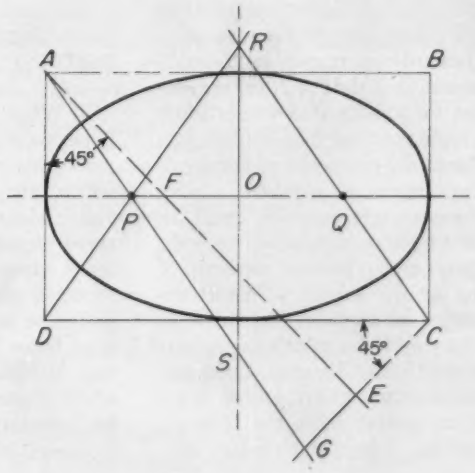
Tips and Techniques

Ellipse Construction

This simple construction for an approximate ellipse requires only a 45 deg triangle and a compass. The procedure to draw an ellipse in rectangle *ABCD* is:

1. Draw two 45 deg lines down from *A* and *C* as shown, intersecting at *E*. *AE* intersects major axis at *F*.
2. Transfer distance *OF* to line *CE*, extending *CE* to *G*.
3. Draw *AG*, intersecting major axis at *P* and minor axis at *S*. Draw *DP* and extend to intersect minor axis at *R*. Draw *CR*, intersecting major axis at *Q*.
4. Draw ellipse from centers *R*, *S*, *P*, and *Q*.

—W. H. SHEPPARD, *Montreal, Quebec.*



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Recommended practices for

Applying Intermittent-Duty Motors

under operating conditions other than rated

S. NOODLEMAN
The B. A. Wesche Electric Co.
Cincinnati, Ohio

INTERMITTENT-DUTY motors are generally defined as motors which will not exceed the allowable temperature rise when loaded in accordance with nameplate rating and operated at the rated ambient temperature condition, continuously, through specified cycles of load, no load, and rest. Certain motors of this type are called "short time duty" motors when they are designed to operate for a definite period of time under rated conditions. Other types of motors may also fall within the intermittent-duty classification if they exceed permissible temperature rise while operating continuously at nameplate rating.

Intermittent-duty motors are designed for applications where small size, higher ratings than conventional standards, or special performance characteristics are required.

These motors may be rated in either torque or horsepower or both. Unfortunately, present methods of rating do not supply sufficient information for applications other than the duty cycle for which the motors were specifically designed. Rules and considerations, which follow, can help to capitalize on the inherent versatility of intermittent-duty motors. Besides the conventional nameplate data, showing required electrical power supply and rated temperature rise, these motors may be rated in terms of torque or horsepower.

1. When motors are rated in terms of torque, the stated torque value is the stalled or locked-rotor torque. The speed shown on the nameplate in rpm indicates the synchronous speed for motors of induction design. For dc motors, nameplate speed is no-load speed. By rating a motor in terms of stalled torque and its no-load speed, the speed-torque curve is generally defined.

2. When a nameplate indicates a horsepower rating, the speed on the nameplate should be the speed at which this power load occurs. These values identify the one point on the speed-torque curve at which the motor is expected to operate. It is not expected that the nameplate horsepower be indicated in standard ratings. Since intermittent-duty motors may be operated over a wide range of conditions, additional data may be necessary to define motor performance.

3. When an induction motor is rated in horsepower, and its operating speed is at or below the synchronous speed of the next lower set of poles, the nameplate should specify the number of poles designed into the motor.

Often, it is desirable to rate a motor in both horsepower and torque. For example, an induction motor is required for a clamping operation. Obviously, the torque characteristics of the motor must be known. But this same motor must run-in the gears of the (clamping) machine. Under this condition, the motor must be capable of operating at some horsepower rating for the specific period during which the gears are running-in. To insure that the motor is satisfactory for both applications, it is desirable to keep the torque rating and add a horsepower rating.

4. When a motor is required to meet a dual rating, the final or predominant use should determine the rating shown in the nameplate heading. Within the nameplate, as a footnote, the additional performance should be specified.

Intermittent-duty motors are de-

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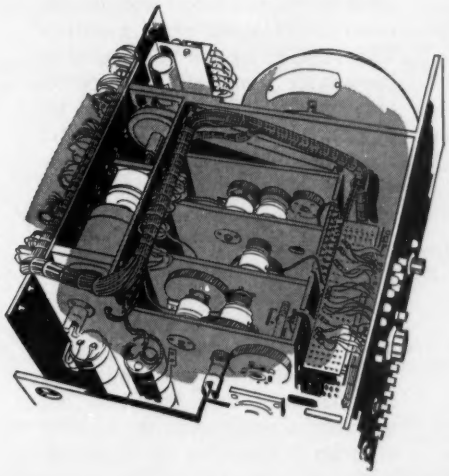

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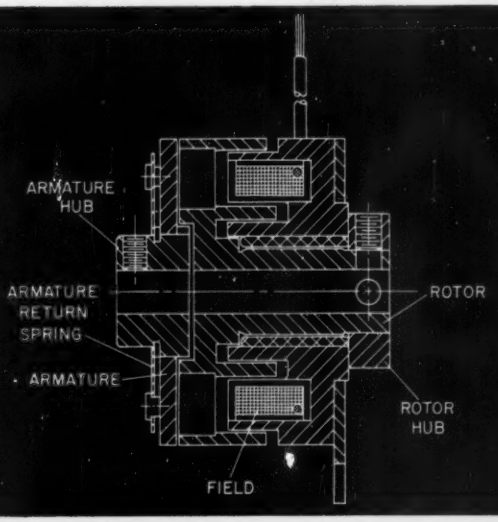

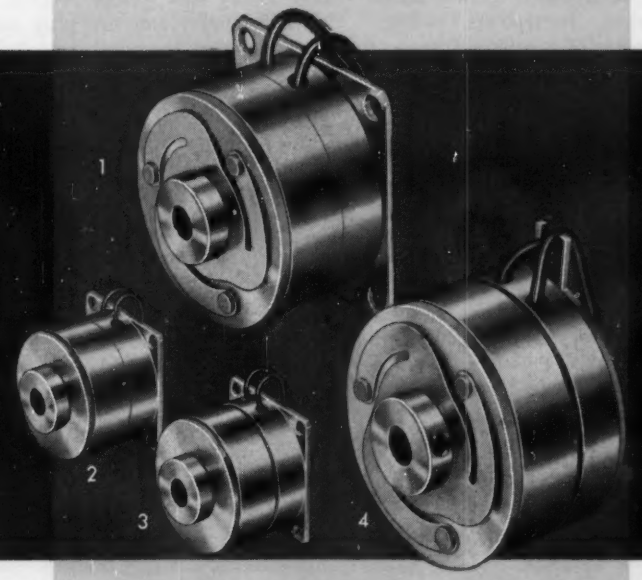

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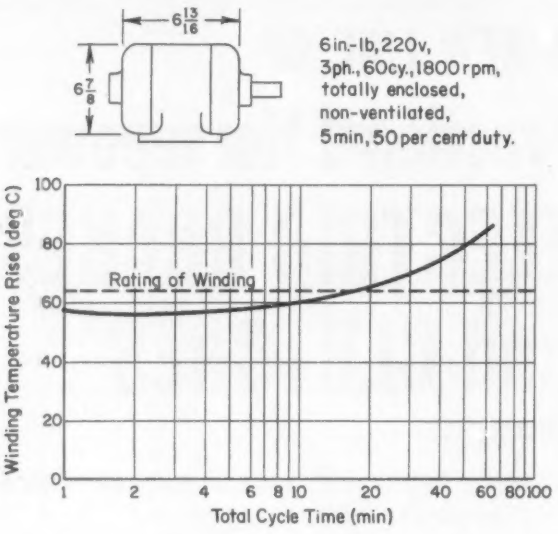

Fig. 1—Temperature performance of a torque motor.

signed for specific applications. Characteristics which are controlled to meet requirements include frame size, torque, horsepower rating, speed, degree of ventilation, type of insulation, and motor inertia.

Operation of the motor over any set of conditions introduces losses into the motor structure. As the motor is started, heat is introduced to develop starting torque. As the motor accelerates, more heat is added to accelerate the load and the rotor itself. As the power drives the load, the difference between input power and output power again adds heat into the motor structure. Lesser heat generators are core loss, stray load loss, friction, and windage loss. Other loss factors peculiar to an induction motor are plug stopping and plug reversing.

Heat is generally dissipated from the motor through the motor frame due to radiation, by conduction from air passing through or over the motor, and by transfer through the motor frame and shaft. Other means such as water cooling or special cooling devices, may be required. The difference between heat losses and heat dissipations determines the time at which the motor reaches its rated temperature.

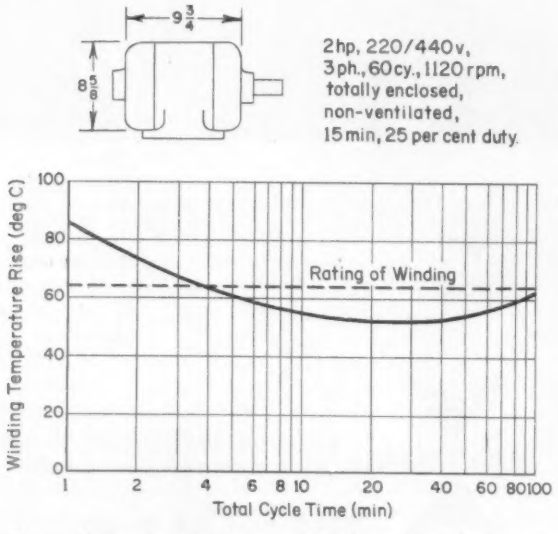

Fig. 2—Temperature performance of an intermittent-duty motor.

5. Ratings of intermittent-duty torque motors should include a time value and a per cent duty cycle. For example, a motor may be rated at 5 min, 10 per cent duty. This means that this motor can be stalled for 5 min at rated ambient temperature before reaching rated operating temperature. The motor must be deenergized for 45 min to permit its windings to cool before another 50-min cycle of operation is permitted. This same motor can be expected to operate for 1 min out of every 10, or 3 min out of every 30, or 5 sec out of every 50. Fig. 1 illustrates the temperature performance of one type of torque motor under these conditions.

When motors are rated in horsepower, different factors affect the relation between the total motor losses and the provisions for heat dissipation. The same method of rating will provide consistent results for the maximum time indicated, but will require derating as the number of cycles of operation are increased.

For example, consider an intermittent duty motor rated at 0.3 hp at 820 rpm, 5 min, 10 per cent duty. Starting, accelerating, and running for 5 min at rated horsepower will cause the motor windings to reach rated temperatures. This same operation can be repeated safely every 50 min. However, whether cyclical operations of 1 min out of every 5 would still permit the motor to perform within its temperature rating would depend upon the amount of heat fed into the motor during starting and accelerating in relation to the heat introduced during running. It would also depend on the heat dissipation during starting, accelerating, and running.

Fig. 2 shows a comparison of ultimate winding temperatures for an intermittent-duty motor rated in horsepower and operating over the same duty cycle, but for a varying number of operations.

6. Certain conditions are assumed in evaluating the number of starts and accelerations to rated speed. Losses developed during acceleration are based on accelerating an external inertia equal to rotor inertia. Tests determine the total number of starts and accelerations per cycle which bring the motor windings to rated temperature. The time cycle is arbitrarily chosen per minute, and this

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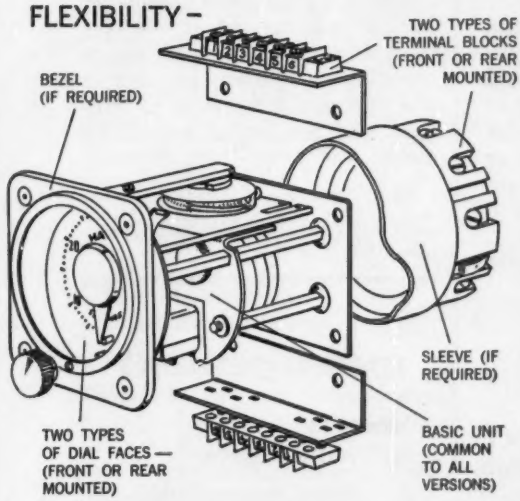
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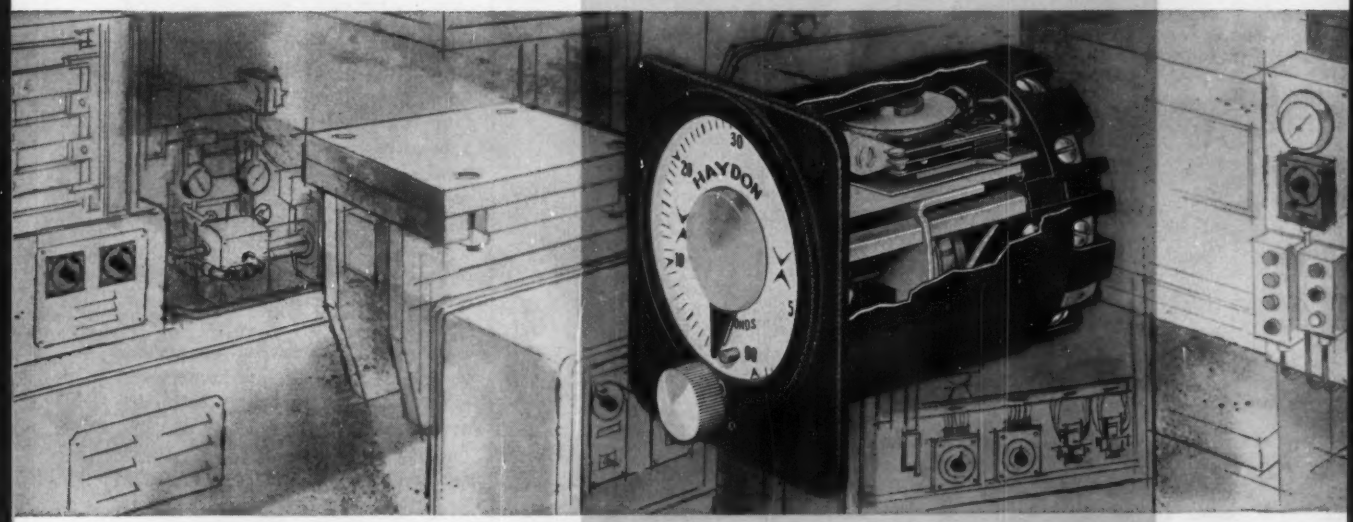

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factor is indicated as starts per minute.

Thus, if tests on the previous 0.3 hp motor showed it was capable of 10 starts per min, its rating would read: 5 min, 10 per cent duty, 10 starts per minute. This rating would specify a 0.3 hp motor capable of starting and running at 820 rpm for 5 min out of every 50 min to operating at 10 starts per min or one start and acceleration to rated speed and run for 0.6 sec, off 5.4 sec.

AIEE Paper No. CP-60-1258, "Intermittent Duty Motors," presented at the AIEE Fall General Meeting, Chicago, October, 1960, 5 pp.

management

How to be A Creative Engineer

C. R. Hocott, manager, Humble (Production Research) Division, Humble Oil and Refining Co.

Some of the more obvious aspects of creativity. Desire for improvement is probably the most important ingredient in the makeup of a creative individual. To be truly creative one must never be satisfied with less than the best, and it must be recognized that this best is really a transient thing. The very process of optimization today should generate the desire to do better tomorrow.

Another extremely important characteristic of the creative person is the boldness to venture forth with new ideas.

Every engineer has the basic foundation of knowledge on which to build a creative future. But the fundamentals of college training are merely the starting point. The rate of growth of new knowledge is so great that engineers must cultivate the ability to study, motivated by an insatiable desire to learn.

Along with knowledge and understanding in promoting creativity, engineers must cultivate an alertness that can come only through careful attention to details.

The crowning aptitude for creativity is imagination. Most children are endowed with it. Adults still have it to the extent it has not been suppressed. It can be cultivated

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and developed to a high degree.

Truly creative activity depends primarily on diligent pursuit. In this pursuit, seek a clear definition of objectives, plan thoroughly the course of action, and forecast the results while withholding judgment. Then carefully execute the plan, and with deliberate alertness observe developments.

ASME Paper No. 60-PET-8, "You, Too, Can be a Creative Engineer," presented at the Petroleum Mechanical Engineering Conference, New Orleans, Sept., 1960, 4 pp.

techniques

Role of Reliability In Engineering Design

I. Doshay, Aerojet-General Corp.

Techniques of data development through statistical reduction methods, which, in part, constitute reliability procedure. Also considered is the application of reliability relationships through engineering techniques, and assurance of reliable design through design review.

Primary purpose of design review is to determine the extent to which the required design factors, such as performance, weight, and size, are being attained. Review also provides management a means of monitoring and controlling the development of design. Design review should cover:

1. Assignment of primary responsibility
2. Review time and date for: Block diagram, completion of preliminary schematic, mechanical design of packaging, basic layout, first lab model, and first production model.
3. Determining attendance at review
4. Providing background data
5. Establishing programming goals
6. Description of required design
7. Listing sources of design in order of decreasing confidence
8. Review of requirements and specifications
9. Design discussion
10. Alternative designs
11. Calculations and laboratory analysis that prove design
12. Selection and application of components and materials
13. Power requirements
14. Listing special facilities and test equipment

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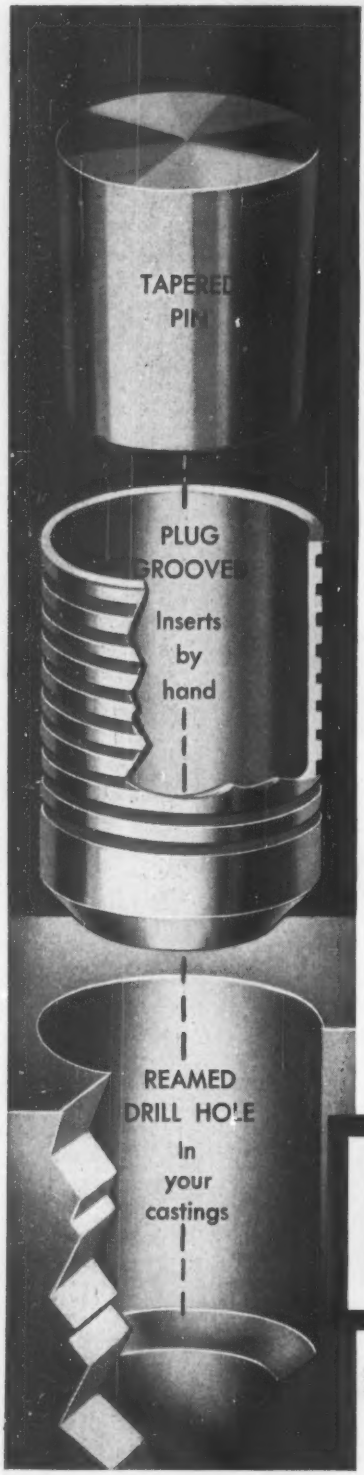

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15. Preparation and distribution of design inventory.

SAE Paper No. 235A. "Reliability Implementation in Engineering Design," presented at the SAE National Aeronautic Meeting, Los Angeles, Oct., 1960, 14 pp.

Developments in General-Purpose Digital Computers

Charles P. Bourne and Donald F. Ford, Computer Techniques Laboratory, Stanford Research Institute

Important characteristics of all general-purpose digital computers that have ever been built or are in the process of being built. The collected data seem to suggest that the majority of the computers developed between 1960 and 1965 will show very little change in performance from that which was obtained during the past five years. Appendix B is a directory of approximately 300 different computers.

Paper No. 1.1, "The Historical Development and State-of-the-Art of General Purpose Digital Computers," presented at the Western Joint Computer Conference, San Francisco, May, 1960, 21 pp.

The Outlook for Machine Translation

Franz L. Alt, National Bureau of Standards

A survey of the main difficulties in the way of language translation and the methods that have been proposed to overcome them. Three approaches to semantic problems are statistical, systematic and empirical. The same three methods can be distinguished in dealing with syntactic problems.

The statistical approach consists of searching through large amounts of source texts and enumerating the frequency of certain word sequences. The systematic approach attempts to set up a system of rules—a machine program—which analyzes the syntactic structure of each sentence. The empirical approach starts by selecting a few very simple rules for translation, tries them on a body of text and notices where they fail, corrects the rules or introduces new ones to cope with the observed failures, tries the revised rules on a larger body of text, and so forth.

The most important mechanical

translation projects in Western countries are enumerated. Whichever will be the final choice, it does seem likely that some system will be found whereby machine translation will be considerably more economical than human translation.

Paper No. 7.2, "The Outlook for Machine Translation," presented at the Western Joint Computer Conference, San Francisco, May, 1960, 6 pp.

Optimized Data Systems

John C. O'Brien, Nortronics-Systems Support, a division of Northrop Corp.

The basic task of data systems, which include all types of testing, sensing, and surveillance instrumentation, is to acquire, transfer, and interpret information correctly. Until recently, such systems have not enjoyed the blessing of well-integrated fundamental analytical laws of performance, such as have been developed for communication systems. However, the similarity between the transfer of time functions of information, such as messages, and the acquisition of meaningful data from physical situations, such as a surveillance area or test situation, suggests the adaptation of information theory to the specific problems of data handling. This can be done by extending the time functions involved in communication to include spatial dimensions, and by converting the pertinent parameters, such as bandwidth, noise, etc., to their spatial counterparts.

WESCON Paper, "Optimized Data Systems," presented in Part 5, Session 37, IRE Western Electronic Show and Convention, Los Angeles, Aug., 1960, 10 pp.

Data Compression

Helmut Schwab, Applied Development Corp.

A data processing operation for reduction of data volume without reduction of specific information. Such compression is desired for bandwidth saving in communication and for simplification of successive data processing operations. Data compression has to be investigated in close connection to data encoding methods for best overall system efficiency.

Typical examples for simple data compression are: Sampling rate reduction, accuracy reduction, incre-

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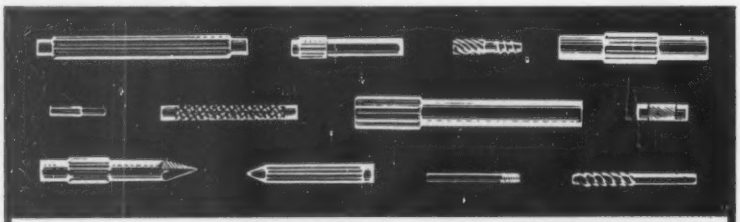

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ment monitoring, event monitoring, source analysis. Data compression is important in space and industrial communication, reconnaissance, and high-speed high-volume data handling.

Compression methods are explained in connection with specific applications and in respect to data encoding problems. Also, some equipment for data compression is discussed.

WESCON Paper, "Data Compression," presented in Part 5, Session 37, IRE Western Electronic Show and Convention, Los Angeles, Aug., 1960, 4 pp.

hydraulic

Selection of Control Valves

Jake E. Valstar, head, Control Systems Sect., Hughes Semiconductor Div.

Mathematical principles underlying the choice of characteristics for a control valve. By simple calculations, a theory can be developed to cover a great number of practical cases. It is shown what can be done with the valve characteristics available on the market today, and it is indicated how these characteristics may be considerably improved for the more stringent requirements of tomorrow. The processes under consideration are supposed to be of linear, or of simple non-linear, structure.

ISA Paper No. 1 SF 60, "The Control Valve as a System Component," presented at the Summer Instrument-Automation Conference, San Francisco, May, 1960, 18 pp.

electrical

Touch Detector

G. T. Kemp, Texas Research Associates Corp.

The solion touch detector—an electrochemical transducer which responds to very small forces incident on a sensitive diaphragm. It is relatively small in size and requires very little circuitry. The expected life is unlimited under normal operation, and the power requirements are extremely small.

There are several possible variations on the basic design, some of which practically eliminate the effect of vibration of the housing. The

Circle 484 on Page 19

frequency response of the detector is determined by the values of the acoustic elements in the device, and the peak frequency is normally selected to be below 200 cps.

WESCON Paper, "Touch Detector," presented in Part 5, Session 8, IRE Western Electronic Show and Convention, Los Angeles, Aug., 1960, 6 pp.

mechanical

Strength Prediction after Stress-Temperature Exposures

D. M. Badger and C. D. Brownfield, Norair Div. Northrop Corp.

Procedures which enable prediction of strength remaining in hardened metallic materials after complex temperature and stress exposures. These procedures are based primarily on application of rate-process theory in the form of the time-temperature parameter $T(C + \log t)$ to the over-aging or annealing reaction. The approach is reviewed in detail for the aluminum alloy 7075-T6. Generalized curves cover strength in tension, compression, bearing, and shear.

SAE Paper No. 228C, "Strength Prediction after Severe and Complex Thermal Histories," presented at the SAE National Aeronautic Meeting, Los Angeles, Oct., 1960, 9 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ISA—Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

WESCON—Western Electronic Show and Convention, Convention Record, Part 5, $1.80 to IRE members, $6.00 to nonmembers, available from Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

Western Joint Computer Conference, Proceedings, three dollars per copy, available from AIEE, or IRE, or Association for Computing Machinery, 2 East 63rd St., New York 21, N. Y.

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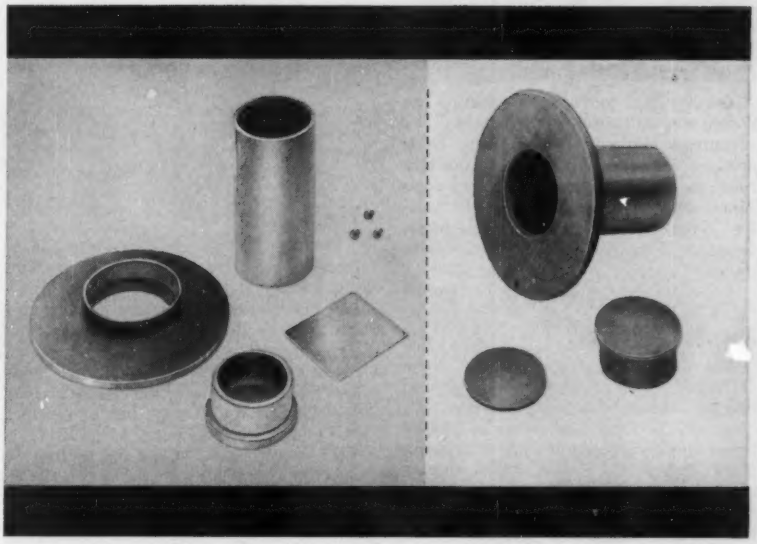

The conventional 7-part stanchion socket shown on the left requires a cast base and tubing, cast cap, brass web and three rivets. Manufacturing it involves some 20 operations including machining, cutting, soldering, drilling, riveting, and final polishing and plating.

In comparison, the cored forging stanchion socket, on the right, developed by Bridgeport's Cored Forging Division requires only 3 parts and a total of 5 assembly operations. The socket and cap are forged to perfect dimensions...only polishing and plating are needed. For the web, a piece of scrap trimmed from the forging is utilized. Just the right size, it requires only a press fit.

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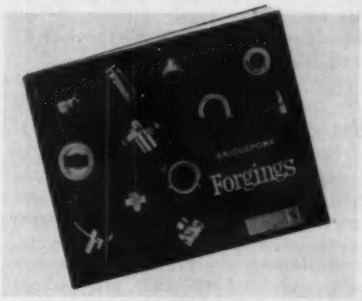

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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Powdered-Metal Parts

New booklet provides information on Powdermet structural parts, pointing out advantages and uses of the parts. Table provides data on mechanical properties. Facts on considerations in designing powdered-metal parts are given for the various types of parts available. 8 pages. American Powdered Metals Inc., North Haven, Conn.

Circle 601 on Page 19

Speed Reducers

"Parallel-Shaft Speed Reducers," Book 2719, describes a redesigned and expanded line of balanced-design parallel-shaft reducers in 57 sizes. Book provides full information for selection of correct drive for every application. Rating tables contain thermal and mechanical horsepower ratings for each input and output speed, and load classes are shown for almost 250 driven machines. Dimensions and actual ratios are included in additional tables. 16 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 602 on Page 19

Electronic Connectors

Illustrated, two-color brochure, Form CC-860, highlights the important features and specifications of Continental printed-circuit, microminiature, subminiature, miniature, and power connectors for missile, aircraft, computer, and communication applications. A few special designs, and detailed description of new crimp-type, removable-contact connectors, are also included. 8 pages. Electronics Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 603 on Page 19

Use of Silicones

"Silicones Solve Space Age Problems" is the theme of a booklet describing more than 25 established applications for silicones in military and commercial aircraft, in missiles, and in ground-support equipment. Reasons why silicones have become basic and vital materials are outlined in the reference, which covers such products as fluids, rubber, potting materials, sealants, and protective coatings. 8 pages. Dow Corning Corp., Midland, Mich.

Circle 604 on Page 19

Hydraulic Cylinders

New bulletin covers 3000-psi, Series 3H hydraulic cylinders. It includes tables and engineering drawings which provide all dimensional data for the various models and sizes. Included also are data on mounting brackets, oversize rods, and clevises. Engineering notes on cushions, ports, and pistons are incorporated. 16 pages. Panthon Mfg. Co., 3823 Pacific Ave., Cincinnati 12, Ohio.

Circle 605 on Page 19

Timing Devices

Product Bulletin 5907, "Timing Unlimited," describes typical electronic timing devices and controls. Technical data and typical timing diagrams are included for sequence timers, flashers, intervalometers, programmers, pulse-train generators, repeat-cycle timers, time-controlled voltage sensors, and electronic stepping switches. 6 pages. Tempo Instrument Inc., P O Box 338, Hicksville, L. I., N. Y.

Circle 606 on Page 19

Small-Parts Conveyors

Bulletin describing small parts-handling conveyors is now available. Construction features of cleated-belt conveyors for general, light, and heavy duty are explained and illustrated, with photographs showing both the product and its application in each instance. Two magnetic conveyors are also fully described and illustrated. 8 pages. Rapids-Standard Co. Inc., 342 Rapistan Bldg., Grand Rapids 2, Mich.

Circle 607 on Page 19

Spherical Bearings

Catalog 560 provides comprehensive technical and engineering data, diagrams, specifications, illustrations, and typical applications for Spherco spherical bearings and rod ends. Bulletin points out features of precision, quality, performance, and economy in linkage applications. 16 pages. Sealmaster Bearing Div., Stephens-Adamson Mfg. Co., Ridgeway Avenue, Aurora, Ill.

Circle 608 on Page 19

Plastic Valves and Fittings

New circular describes in detail various products available in corrosion-resistant polyvinyl chloride. Comprehensive application table rates PVC's effectiveness on over 300 fluids. Another section gives illustrated descriptions and dimensions of all PVC valves, strainers, unions, fittings, and expansion joints. Pictures, tables, and line drawings are included. 16 pages. Walworth Co., 750 Third Ave., New York 17, N. Y.

Circle 609 on Page 19

Panel Meters

Data Sheet 601 lists 92 standard models of voltmeters, ammeters, milliammeters, and microammeters in each of three sizes—2½, 3½, and 4½ in. Three typical panel-meter photographs are shown, along with dimensional drawings for each size. Standard specifications include 2 per cent of full-scale accuracy in dc models, 3 per cent in ac models. Data tables include meter sensitivity, standard coil resistance, and standard voltage drop. 4 pages. Helipot Div., Beckman Instruments Inc., 2500 Fullerton Rd., Fullerton, Calif.

Circle 610 on Page 19

Electromagnetic Drives

Booklet B-7875 describes how electromagnetic drives work, what they include, and where they are used. In addition, various types of drives are discussed. Associated with each type, the excitation system, optional operating functions, and mechanical features are reported in detail. 12 pages. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 611 on Page 19

Quick-Disconnect Couplings

Straight-through, quick-disconnect couplings for use on military and commercial aircraft, missiles, test, and ground servicing equipment are described in new catalog. It enlarges upon the advantages of the ball-valve couplings, and gives dimensions, specifications, and ordering information for four standard models. Dimensional drawings, tables, and graphs are included in the catalog. 12 pages. Special Products Div., Weatherhead Co., 300 E. 131st St., Cleveland 8, Ohio.

Circle 612 on Page 19

Balancing Valve

Bulletin 204 describes Illinois dual-purpose, hot-water balancing valve, which takes the place of two valves normally used in series on the return line of a water coil. Cutaways, line drawings, dimensional drawings, and tables are incorporated to present pertinent data. 4 pages. Dept. Pd, American Air Filter Co. Inc., 215 Central Ave., Louisville 8, Ky.

Circle 613 on Page 19

Vibratory Parts Feeder

Booklet includes information on the feeders which provide automatic, oriented-position, single-line feeding of various sizes and shapes of parts. Units are pictured, and all information on dimensions and specifications is included. Design features are pointed out, and applications are shown. 18 pages. Syntron Co., 260 Lexington Ave., Homer City. Pa.

Circle 614 on Page 19

appearances are not deceiving

THIS P&B 10-AMP RELAY IS AS RELIABLE AS IT LOOKS

Our AB relay looks rugged . . . and it is. You can specify it for 10 amp switching and confidently expect 100,000 cycles. Yet it is compact, easily mounted, and does not require special handling. Installation is simple, using your preference of screw terminals (adapters), quick connects, or dip soldering.

Designers specify the AB for air conditioners and other products where dependable, continual service is paramount.

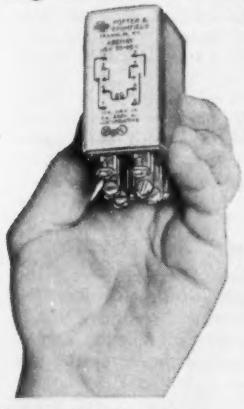
These standard AB and ABC relays are listed by Underwriters' Laboratories and Canadian Standards Association:

Type	Arrangements	Type	Arrangements
AB7AY	DPST-NO	ABC7AY	DPST-NO
AB8AY	DPST-NC	ABC8AY	DPST-NC
AB11AY	DPDT	ABC11AY	DPDT

Coil voltages: 6, 12, 24, 115 and 230 volts AC, 50/60 cycle.
Contact rating 10 amps, 115 volts AC or 5 amps, 230 volts AC noninductive.

U/L File E-29244 CSA No. 15734

Write for complete data or contact your nearest P&B sales engineer.



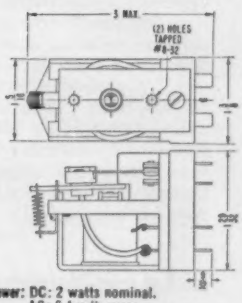
ABC Series—AB series can be supplied enclosed in sturdy metal dust cover, $1^{31}/_{64}$" x $2^{13}/_{32}$" x $2^{1}/_{32}$".

AB AND ABC RELAYS ENGINEERING DATA

GENERAL:
Insulation Resistance: 100 megohms minimum.
Life: 3 million cycles (mechanical).
Breakdown Voltage: 1500 volts rms between all elements and ground.
Temperature Range: DC: −55 to +45°C.
AC: −55 to +45°C.
Weight: AB—5 ozs. ABC—7 ozs.
Terminals: Fit ⅛" quick-connect terminals, or may be applied to printed circuits using dip soldering. Screw adapters furnished on request.
Enclosure: ABC: Heavy duty dust cover.
Dimensions: $1^{31}/_{64}$" x $2^{13}/_{32}$" x $2^{1}/_{32}$".

CONTACTS:
Arrangements: DPDT
Material: ¼" dia. silver. Other materials available.
Load: 5 amps at 230 volts AC or 10 amps at 115 volts AC noninductive.
10 amps at 28 volts DC.

COIL:
Voltage: DC: 6 to 110 volts.
AC: 6 to 230 volts.



Power: DC: 2 watts nominal.
AC: 6.4 volt-amps.
Resistance: 35,000 ohms max.
Duty: Continuous: DC coils will withstand 6 watts at +25°C.

MOUNTINGS:
AB: Two 8-32 tapped holes on 1⅛" centers.
ABC: One 8-32 stud ⅞" long and locating tab.

P & B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

Circle 486 on Page 19

Color-Coated Stainless

Bulletin B-59-3, "ColorRold Stainless," gives general information, characteristics, physical and mechanical properties, and applications for color-coated stainless-steel sheet and strip. Separate card shows complete color range. 8 pages. Washington Steel Corp., Washington, Pa.

Circle 615 on Page 19

Gages and Controls

Pressure gages, thermometers, and control instruments are described in Bulletin 3020. Photographs illustrate each of the gage types covered, with information on dimensions, accuracies, construction features, and suggested uses given in the text. Included under temperature measurement are dial and glass-tube thermometers, panel-type, and multiangle thermometers. Control instruments included are indicating controllers, valve positioner and pilot options, recorders, chemical attachments, and accessories. 6 pages. United States Gauge Div., American Machine & Metals Inc., Sellersville, Pa.

Circle 616 on Page 19

Pneumatic Computing Relay

Sorteberg Force Bridge, a pneumatic computing relay, is described in Catalog 53CR1000. Detailed application data are listed for each of the computer's operations, including: Multiplication, division, squaring, square-root extraction with pressure compensation, simultaneous multiplication and division, and ratio setting. Operation and design features are also described. 8 pages. Fischer & Porter Co., 547 Jacksonville Rd., Warminster, Pa.

Circle 617 on Page 19

Servo Components

Revised "Technical Information for the Engineer—Servo Motors, Motor Generators, Synchros," describes in detail the important technical aspects associated with servo components and their use in systems. Complete with diagrams, charts, outlines, tables, schematics, definitions, and formulas, publication offers a convenient reference for designing high-performance servo systems. 56 pages. Kearfott Div., General Precision Inc., 1150 McBride Ave., Little Falls, N. J.

Circle 618 on Page 19

Nickel-Iron-Molybdenum Alloy

Blue Sheet EM-30, "Allegheny Ludlum Moly Permalloy," gives detailed background on this special alloy for use in the electronic industry. Included is information on testing data, hysteresis loops, heat-treating data, magnetization curves, core-loss graphs, and typical physical, mechanical, and magnetic properties. 16 pages. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

Circle 619 on Page 19

Flexible Shafts

Revised Fourth Edition of Flexible Shaft Handbook provides a simplified approach to the selection of flexible shafting through the use of standard, pre-engineered, or custom-designed shafts. Descriptive material, charts, tables, and drawings are included. Information on a new, simplified engaging system, based on integral formed square drives, is also incorporated. Handbook describes the advantages of flexible shafts, their function, and successful applications. Section of tables and statistics is also included. 90 pages. Dept. P, S. S. White Industrial Div., 10 E. 40th St., New York 16, N. Y.

Circle 620 on Page 19

Power-Transmission Equipment

Catalog 103B describes a full line of modern power-transmission equipment and conveyor supplies. Included are perforated, open-end belting, Super 358 V-belt drives, gear motors, fan-cooled speed reducers, chain drives, conveyor pulleys, and other transmission items. Catalog includes prices, specifications, and helpful engineering data. 68 pages. Rockwood Pulley Mfg. Co. Inc., 20 Crosby St., New York 13, N. Y.

Circle 621 on Page 19

Corrosion Computer

New 4 x 8-in. card works like a slide rule and indicates in seconds how each of eight types of metal withstands the corrosive effects of 141 chemical agents. Metals are brass and naval bronze; silicon bronze; Monel metal, stainless types 410, 416, and 430; stainless types 302, 303, 304, and 305; stainless type 316; copper, and aluminum. Computer notes variations with a number of footnotes on the face of the computer keyed to numbers in the answer window. H. M. Harper Co., Morton Grove, Ill.

Circle 622 on Page 19

Square-Head Cylinder

High-pressure square-head cylinder is described in Bulletin SH-6-60. Bulletin offers general and technical information, model and mounting dimensions, and specifications for the interchangeable cylinder. Many tables, dimensional drawings, and a large cutaway photograph are included. 16 pages. Tomkins-Johnson Co., 2425 W. Michigan Ave., Jackson, Mich.

Circle 623 on Page 19

Adjustable-Speed Drives

Bulletin GEA-6806 describes new ¼ to 25 hp Polydyne mechanical adjustable-speed drives. Bulletin discusses principles of operation, configurations and features, and includes mounting positions, rating tables, and description of available accessories. Also discussed are the benefits of mechanical adjustable-speed drives, and how to select and specify Polydyne units. 16 pages. General Electric Co., Schenectady 5, N. Y.

Circle 624 on Page 19

Worm-Gear Drives

Application, selection, and order information for Radicon enclosed, fan-cooled, worm-gear drives are detailed in Engineering Catalog RCB. Material includes AGMA standards; design features; general specifications and sectional views; application data; selection and ordering procedures; rating tables; and permissible overhung and thrust loads. Section three provides details and measurements of the model types available. About 35 pages. Dept. MJ, Foote Bros. Gear & Machine Corp., 4545 S. Western Blvd., Chicago 9, Ill.

Circle 625 on Page 19

Strain Gages

New SR-4 strain gage specification and price list 4310-60 contains price information and technical specifications for over 350 types of strain gages, plus a complete line of strain-gage instruments and accessories. Gages listed include SR-4 and photoelastic Strainline gages, plus monofilament gages and strain inserts. Pictures, tables, graphs, and general strain-gage information are included. 28 pages. Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass.

Circle 626 on Page 19

Industrial Switches

"Switches for Industry," Form 84-441, features an adjustable-pulse switch, center-neutral limit switch, and proximity switch. Illustrated are a wide variety of limit, explosionproof, basic, pushbutton, mercury, and toggle switches for use on machine tools and other industrial equipment. 4 pages. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 627 on Page 19

Flexible Hose

Interesting, informative facts about flexible plastic vacuum hose are presented in a new brochure. It contains diameters, lengths, construction details, and present applications on a complete line of flexible hose ranging from ¼-in. hose for laboratory and medical equipment to large-diameter vent hose. 8 pages. Dayton Dayflex Plastics Co., Div., Dayco Corp., Dayton 1, Ohio.

Circle 628 on Page 19

Stepping Switches

Two-color Catalog 202 contains complete data on construction features, circuitry, and performance characteristics of spring-driven, cam-operated, and direct-drive stepping switches. Mounting accessories, sealed, and dust-cover enclosures, are pictured and described. 40 pages. C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.

Circle 629 on Page 19

Electric Motors

Condensed Motor Data and Price Bulletin 150 contains useful information for designing, selecting, and specifying electric motors. Catalog gives construction, dimension, and price data on comprehensive line of fractional and integral-horsepower motors, and also describes many motor modifications available. Book illustrates special designs of various types to suggest practical ways of solving unusual job problems. 14 pages. Write on company letterhead to Doerr Electric Corp., 100 N. Fourth Ave., Cedarburg, Wis.

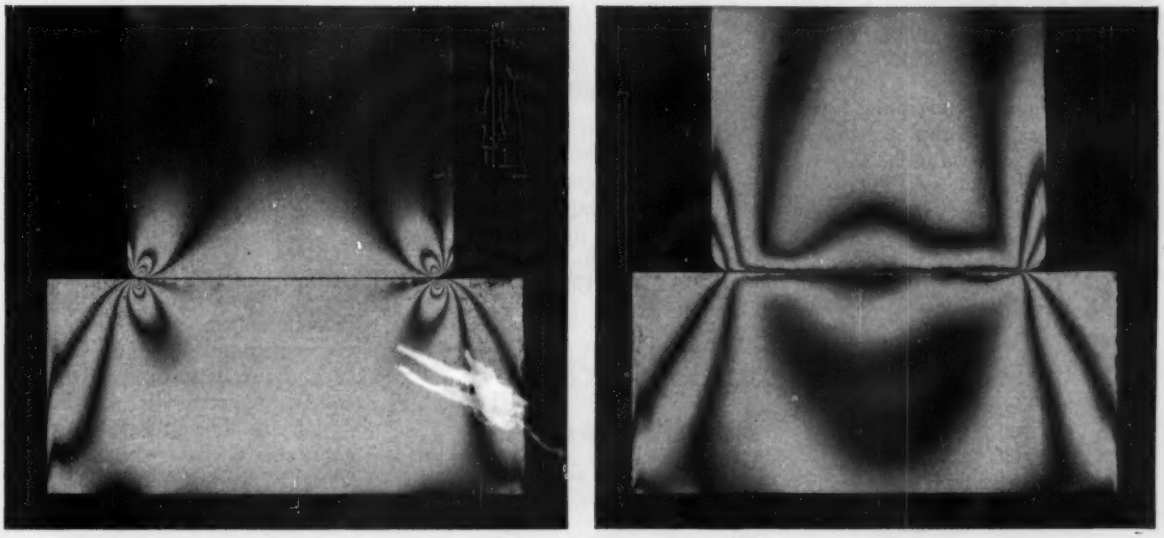
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION



These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 487 on Page 19

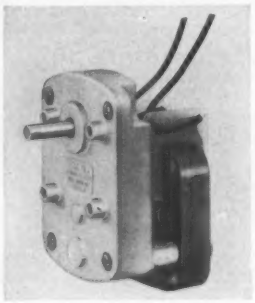
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Gear Motor

has enclosed helical gears

Compact, enclosed gear motor with field mounted directly behind gear housing has output speeds from 6 to 120 rpm with output running torques of 12 lb-in. at 6 rpm for continuous duty. Unit is designed for use in vending machines, business machines, photocopy machines, displays, and as a control device in large equipment. Motor can be geared for a variety of speeds higher



and lower than standard, and wound for higher torques at intermittent loads. Nylon bobbin is UL-tested for temperatures to 120 C. Helical rotor pinions and linen-base phenolic gears in the first stage keep noise to a minimum without power loss. Hardened spur gears and pinions are used in the other stages, with lifetime-lubricated, porous-bronze bearings throughout. Brake or clutch can be built in without dimensional increase. **Brevel Products Corp.**, 639 W. 26th St., New York 1, N. Y.

Circle 630 on Page 19

All-Metal Seal

withstands peak pressure of 40,000 psi

Bar -X-, an all-metal seal, withstands temperatures from −450 to 1200 F and peak pressures of 40,000

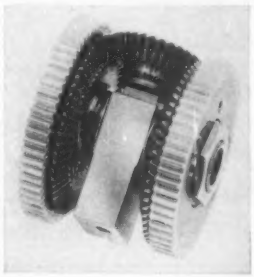
psi. Cross section of the new seal (shown) has an X-configuration which is suited to provide elastic deflections and high sealing forces. Seal can be used for both static and dynamic applications. **E. B. Wiggins Oil Tool Co. Inc.**, 3424 E. Olympic Blvd., Los Angeles 23, Calif.

Circle 631 on Page 19

Miniature Differentials

have backlash as low as 1 min of arc

Miniature, precision, hollow-shaft, three-gear differentials are for use in miniaturized analog computers and closed-loop systems for mechanical comparison or error measurements. Tumbling circle of the differentials is 1.032 in. Adustable backlash can be held as low as 1 min of arc. No special clearance opening is needed for mounting. Differential is slipped into place between two bearing supports, and a solid shaft is threaded through. Simple clamping action locks hol-



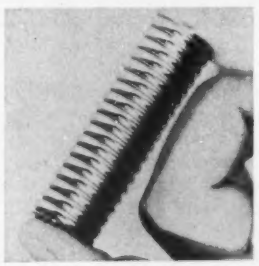
low-shaft differential to the solid shaft. End gears or input gears are readily removable and interchangeable. Differential is adjusted to desired tolerances by tightening or loosening two self-locking nuts on the outside of the end gears. Units are available in ⅛ and 3/16-in. hollow-shaft bores. Gears are Precision Class 2, and bearings are ABEC-5. **Guidance Controls Corp.**, 110 Duffy Ave., Hicksville, N. Y.

Circle 632 on Page 19

Spring Wire

for use at temperatures to 1800 F

Vacuum-melted, nickel-base alloy wire, designated Rene' 41, is available for use in springs to be operated at temperatures to 1800 F. Wire is available annealed to spring tempers in diameters from 0.200 to 0.004 in. Tensile strength in spring



temper ranges from 250,000 to 280,000 psi. Modulus of elasticity ranges from 31.6 million psi at room temperature to 20 million psi at 1700 F. **National-Standard Co.**, Niles, Mich.

Circle 633 on Page 19

Hydraulic Pump

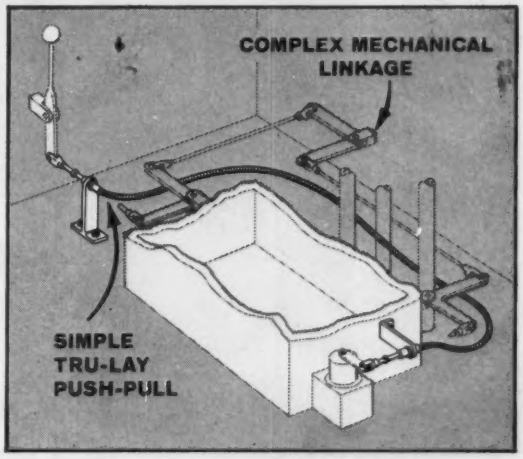
delivers 13.1 hp at 40,000 rpm

Model 905 piston-type hydraulic pump operates at a speed of 40,000 rpm. Rotating group of the unit weighs only 6.7 oz, and is so small

ACCURATE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

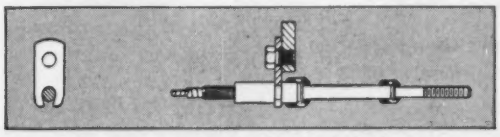
— — with Tru-Lay *PUSH*-PULL Controls

If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over short or long distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are n[illegible]less and give a lifetime of accuracy. Mechanical linka[illegible] on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, vibration rattles and lost accuracy.

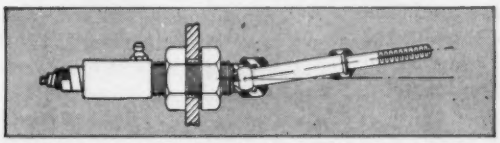


THESE FEATURES HELP SOLVE DESIGN PROBLEMS

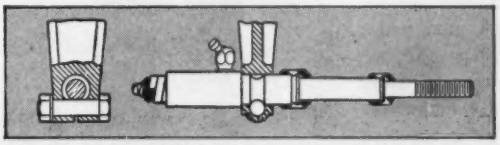
Anchorages



Clip anchorage • a simple clip for light loads

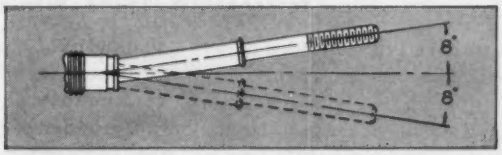


Bulkhead anchorage • for heavy-duty installations



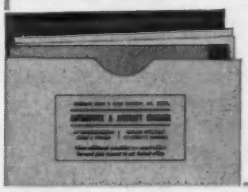
Machined bracket anchorage • can be furnished for mounting any PUSH-PULL cable at the swivel terminal

Swivel Action



Standard assemblies have end fittings with a swivel movement of ± 8° to compensate for misalignment and rise or fall of lever arms. Swivel joints, and the sliding ends, are sealed against dirt and moisture.

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN



• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

ACCO

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.

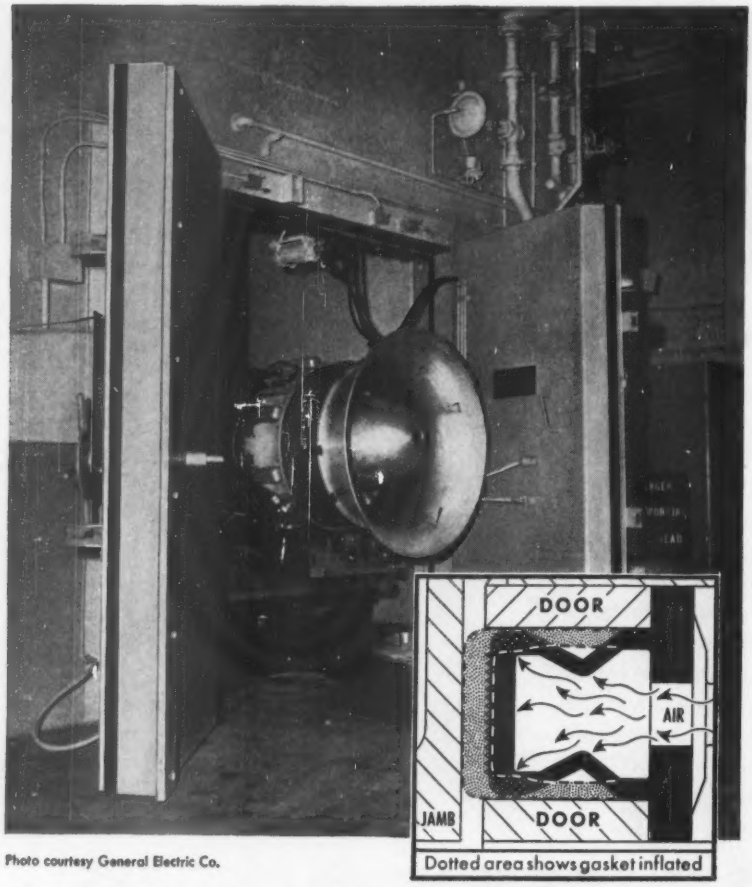


Photo courtesy General Electric Co.

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners*. Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle or as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

that it fits inside the piston bore of larger units. Despite its compact size (2.5 in. diam x 2.7 in. long), pump delivers 13.1 hp at 40,000 rpm. At lower speeds it has a volumetric efficiency of 98 per cent and an over-all efficiency of 90 per cent. Flow response is 30 millisec or less. Pump is particularly well suited to missile work because of its light weight, compact size, high reliability, and flexibility in packaging. **Vickers Inc., Div., Sperry Rand Corp.,** Detroit 32, Mich.

Circle 634 on Page 19

Epoxy Coating

is 100-per cent solids, single-component type

HumiSeal 1F56 is a 100-per cent solids, epoxy, single-component coating for continuous operation to 155 C. The high-temperature, rigid epoxy system is curable at elevated temperature for a short period of time. Heavy coatings are obtainable. Viscosity can be adjusted to yield build of 10 mils and thicker. Coating can be applied either by dip or brush. **Columbia Technical Corp.,** 24-30 Brooklyn-Queens Expressway West, Woodside 77, N. Y.

Circle 635 on Page 19

Flat Nylon Washer

for use on any screw, bolt, pin, nail, or rivet

Flat nylon washer is suitable for use as a spacer or as an insulator, and can be used on any screw, bolt, pin, nail, or rivet. Because of the low coefficient of friction of nylon against metals, washer provides an inexpensive bearing that requires no lubrication. It can also be used to prevent corrosion as the nylon insulates dissimilar metals. Washer cushions the pressure of the fasten-

Circle 489 on Page 19

APPROACH YOUR DESIGN PROBLEMS from ANY ANGLE

with Eastman Low Cost Industrial SWIVEL CONNECTORS

Licensed Under Pat. No. 2481404

Yes, you can approach your design problems from *any angle*—from any of the six sides of EASTMAN'S *newly improved* Industrial Swivel Connector.

Never before has any fitting equaled its adaptability and versatility. You can stack them, line them up parallel, horizontal or vertical . . . in a "T," if need be.

Not only can you simplify design problems, but you can improve the maneuverability of your equipment . . . raise or lower buckets or blades. You are able to change the angle of the cut right or left, up or down . . . *on the go.*

EASTMAN Industrial Swivel Connectors eliminate costly hose failures due to excessive flexing; permit use of shorter lengths of hose and help eliminate complicated assemblies.

Improved interior design provides "balanced" fluid flow *at any angle.* Chrome hardened, cadmium plated interior surfaces, burnished to a mirror finish, improve performance. SIX sealing rings: 2 leather dust seals, 2 synthetic back-up washers and 2 quad rings of oil-resistant rubber (−40° to +200°) assure dust-free field service and less down time.

If you have been "designing around" Swivel Connectors because of high cost . . . rest assured that EASTMAN'S Industrial Swivel Connectors will not only reduce your original cost but lower your customers' operating costs as well.

Exhaustive Tests at 3000 p.s.i. through 1½ million cycles, with the connector covered with abrasives and dirt, simulating field conditions, proved EASTMAN'S Industrial Swivel Connector satisfactory in every respect and did not cause failure of any kind.

Cut corners while you cut costs with these economical Eastman Industrial Swivel Connectors.

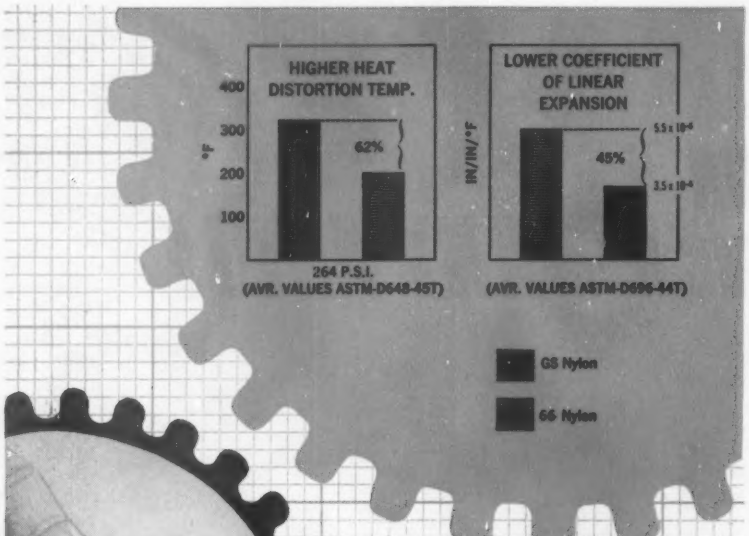
Eliminate installations of lengthy, complicated hose assemblies, junction boxes and multiple adapters.

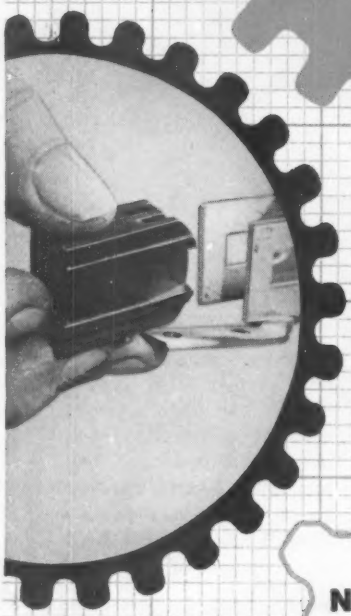
Improve uniform power delivery and operating efficiency, reduce costly field replacement and down time.

- **LOW TORQUE**—Freedom from friction, even under high pressure.
- **WIDE RANGE**—Operating pressures up to 3000 p.s.i. trouble-free operation through wide temperature range (−40° to +200°).
- **ROTATION**—Full 360° for all manifolds.
- **SIZES**—Steel, plated for corrosion protection—½", ¾", 1", 1¼". Other sizes available on request.

Write for Technical Bulletin No. 59 on Eastman's new improved swivel connector.

Eastman MANUFACTURING COMPANY
DEPT. MD-10 MANITOWOC, WIS





With a coefficient of linear thermal expansion approximately half that of 66 nylon, NYLATRON GS nylon provides excellent size control and accurate molding tolerances. In this oven door slide lockstop, a tolerance of +.003" —.000" is essential. Tests conducted at 12 to 20 cycles per minute at temperatures to 284°F. equalled 30 years service.

look
how much more
dimensional stability
NYLATRON® GS Nylon
gives your product

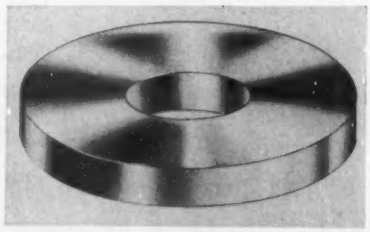
NYLATRON GS nylon fortified with molybdenum-disulfide has many important design features other nylons lack. Better dimensional stability is only one. Others include: greater strength and wear resistance, less deformation under load, and increased modulus of elasticity. Also NYLATRON GS nylon ejects rapidly from the mold and handles easily on standard injection equipment.

These plus properties mean NYLATRON GS nylon can produce a superior product at the same time it simplifies engineering, steps up design accuracy, meets precise specifications . . . and, in many cases, cuts costs.

For information about the unique properties and advantages of NYLATRON GS injection molding compound, call or write The Polymer Corporation

POLYPENCO *industrial plastics*

The Polymer Corporation • ***Molding Resins Division***
Reading, Pa.



er and permits it to seat to the required tightness without danger of cracking, chipping, or crazing of the surface. Washer has a tensile strength of 15,000 psi. It is available in sizes to ½ in. OD to fit screws from No. 3 through ⅜ in. diam. **Nyltite Corp. of America**, 280 Badger Ave., Newark 8, N. J.

Circle 636 on Page 19

Wire Cloth

is Teflon coated

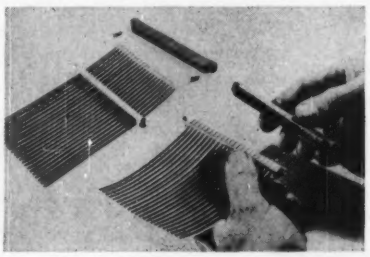
Teflon coating can be applied evenly over the entire surface of industrial wire cloth and will not interfere with mesh openings in mesh sizes as fine as 180 per in. In operations where water is present, Teflon coating tends to hold the water back and allow other liquids to pass through. **Wire Cloth Dept., Cambridge Wire Cloth Co.**, Cambridge, Md.

Circle 637 on Page 19

Multiconductor Cable

only 0.012-in. thick

Two types of weight and space-saving multiconductor cable, only 0.012-in. thick, and a variety of connecting devices are now available. Flexible, flat cable, Contour Cable, meets rigid military performance specifications for all types of harnesses—interconnecting cables, rotary-joint connections, movable rack and panel-drawer connections, and other wiring configurations. Etched and continuous Contour Cable is



(What's wrong with this picture?)

Are your "dead storage" files more efficient than your active drafting files?

No doubt about it—it's very important to keep correspondence carefully and safely filed; *but* certainly as important to equip your drafting department with modern filing facilities that keep your active and semiactive drawings totally accessible—in a minimum of space—and protect them fully.

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment—from Dietzgen

The equipment in your drafting room, perhaps more than any other equipment you have, helps determine total productivity through the practical creativity of your engineer-draftsmen. Because Hamilton equipment *is* engineered to deliver maximum savings in time and space—it is basic to accuracy, motion economy, lessened fatigue—functional and human factors that determine total efficiency.

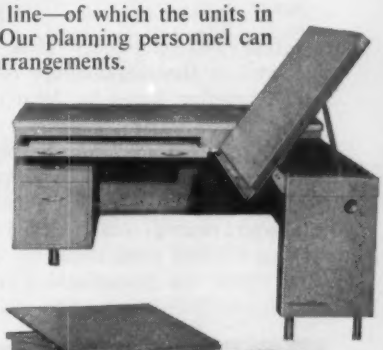
Inadequate or antiquated equipment in your drafting room can't help but cost you money, foster errors, as well as cumulative losses.

Hamilton design is basic, practical—thoroughly tested in many thousands of installations. Its rugged construction delivers many, many years of consistent performance.

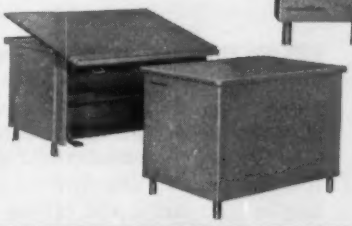
We feature and service the *full* Hamilton line—of which the units in this advertisement are only a small part. Our planning personnel can give you valuable help to determine best arrangements.

Hamilton Plan Files
The Hamilton unit system offers maximum protection and capacity in minimal space. For instance, each drawer of any of our patented shallow drawer units is equipped with a tracing lifting mechanism . . . every tracing becomes a top sheet, instantly accessible. Unit sections can be assembled in a number of arrangements, stacked safely to any practical height. They stand up to hard usage, perform perfectly year after year.

The Hamilton L-Contour Table
A personalized work area concept permitting a wide range of board adjustments, from horizontal to vertical, yet provides considerable storage area and occupies small space. Single support torque tube tilt mechanism provides stable, perfect balance of the durable, seasoned working surface.



Hamilton De Luxe Auto-Shift Table
Completely functional features combined with modern styling, to create exceptional efficiency. Because this table sharply reduces fatigue, it helps you achieve highest quality and peak production. Fully seasoned drawing surface, adjustable to individual height and slope requirements. Quick, easy adjustments. Many features, creating ideal conditions for each individual job. Exceptionally durable, handsome in appearance.



Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-HK160.
Eugene Dietzgen Co., Chicago 14, Illinois

DIETZGEN

EVERYTHING FOR DRAFTING SURVEYING & PRINTMAKING

PRINCIPAL OFFICES: CHICAGO • SAN FRANCISCO
NEW YORK • NEW ORLEANS • LOS ANGELES • CALGARY

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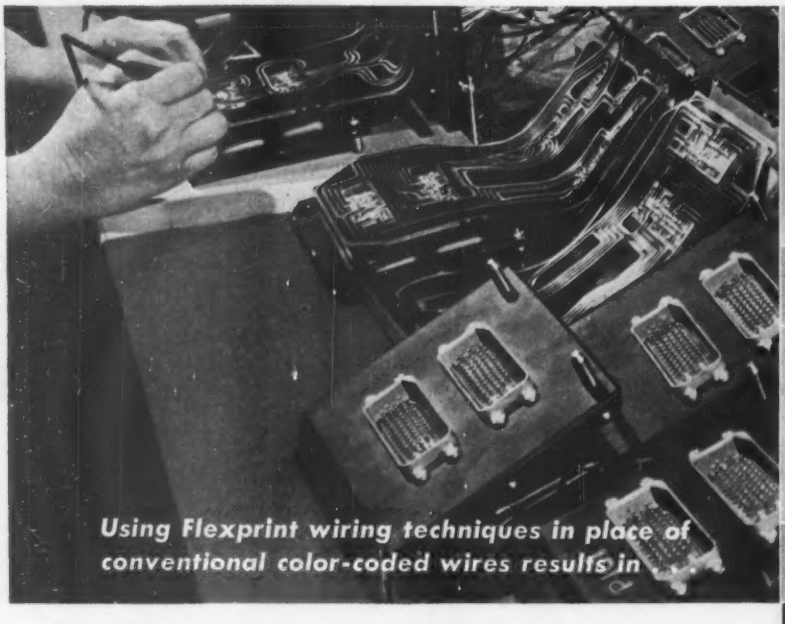
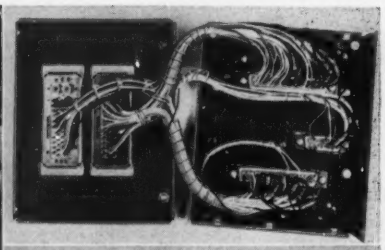
Circle 491 on Page 19





BEFORE — A Costly, Time-Consuming Assembly Problem Using Conventional Wiring

AFTER — Wiring Errors Eliminated; Weight, Cost and Time Saved Using Flexprint Wiring

50% reduction in wiring costs of this electrical assembly

Originally, 82 color-coded wires were involved in the manufacture of airborne junction boxes by John Oster Company, Chicago.

A switch to Sanders Flexprint wiring — flat, flexible printed circuitry — replaced the 82 wires with 5 Flexprint cables and reduced total installed costs of the finished component by 50%. Here's how this money-saving switch was accomplished:

BEFORE FLEXPRINT WIRING, assembly of junction boxes for an airborne electrical system required a costly sequence of assembly line operations: each box called for the selection of 82 color-coded wires . . . cutting them to various lengths . . . lacing and cabling . . . identification and positioning . . . then soldering into tight corners. Opportunities for human error and mounting costs were inherent in the job, as in most electrical assembly work. With conventional wiring one more trouble source occasionally cropped up — closing the junction box created strains on the folded harnesses, and was apt to cause broken connections.

WITH SANDERS FLEXPRINT WIRING, five flat, flexible cables and 4 shields replaced the bulky harnesses (shown). Complete flexibility lessens — virtually eliminates — the likelihood of broken connections when the junction box is once assembled and closed.

WHAT CAN FLEXPRINT WIRING DO FOR YOU? It costs nothing to find out. Just send dimensional drawings, sketches or artwork of your current wired assembles with the following information:

1. Electrical specifications
2. Termination requirements
3. Environmental conditions
4. Approximate quantity

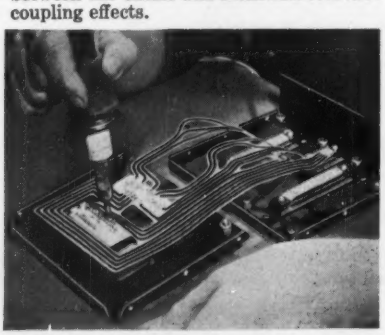
We'll send you a proposal specifying estimated costs and delivery date. Or, if you'd prefer, we'll send you a new brochure describing Flexprint wiring in detail.

FLEXPRINT®

PRODUCTS DIVISION
SANDERS ASSOCIATES, INC.
NASHUA, NEW HAMPSHIRE
Inglewood, California Washington, D. C.

® Trademark Sanders Associates, Inc.; Patents pending in U.S. and abroad.

Five Flexprint cables and 4 copper shields cut 50% of material-labor costs. Each cable is an accurate printed circuit, clearly numbered for easy, progressive assembly. Conductors of Flexprint wiring are totally encapsulated within the insulation except at termination. Terminations are exposed copper pads, pierced to fit pin connectors. The four unitized shields fold between the cables and maintain constant coupling effects.



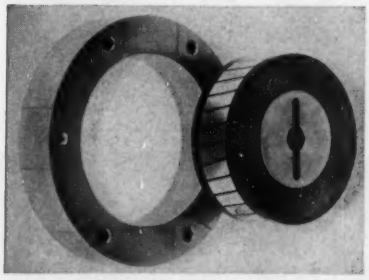
Assembly gets off to a fast start! One-piece Flexprint cables are self-positioning. They locate conductors and terminations with flawless accuracy. Each pierced termination pad automatically fits itself over its own connector pin. Wiring errors are almost impossible! And soldering becomes a high-speed operation because each connection is *completely* visible, not hidden in the connector or lost in a tangle of wires. Assemblers can see at a glance that each connection is tight and right.

produced in a number of material combinations to meet any range of temperatures from −65 to +250 C. Etched cable designed to meet special equipment requirements can be delivered in any length or width, not exceeding 48 x 48 in., to match special circuitry configurations. Continuous rolls of unshielded, electrostatically or magnetically shielded cable are available. Widths up to 5½ in. in conductor sizes from 20 to 28 gage with a variety of spacings can also be supplied. **Industrial Systems Div., Hughes Aircraft Co.**, International Airport Station, P. O. Box 90904, Los Angeles 45, Calif.

Circle 638 on Page 19

DC Torque Motors

are low-speed, pancake-type units



Low-speed, high-torque, dc torque motors are available for use as high-performance torquers or direct-drive servo motors. The pancake-type, multipole, permanent-magnet motors feature low levels of friction and ripple torque, and extremely high values of torque per watt and torque/inertia. Backlash problems are eliminated when used in direct-drive servo applications. Typical unit, 1-7/8 in. OD by ½ in. thick, features 0.35 oz-in. of torque per watt with a peak torque of 20 oz-in. **Giannini Controls Corp.**, 1600 S. Mountain Ave., Duarte, Calif.

Circle 639 on Page 19

DC Tachometer

has low armature inertia

Model SS-779E-1 tachometer weighs less than 1½ oz, and has an overall diameter of only ¾ in. and an armature inertia of 3.5 gm-cm². In spite of its small size, unit has the

THE CARE AND FEEDING

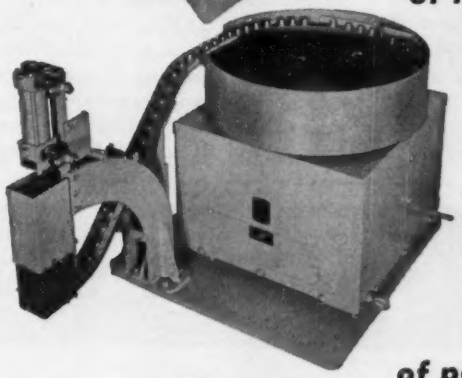
of parts discharged at high or low heights

DPS ELEVATING FEEDERS elevate, orient and feed parts of almost any size, shape and material to other machinery for processing and assembly. High capacity storage bins are designed to assure a steady flow of parts to elevating mechanism regardless of load level.

Orientation of parts is accomplished at discharge point of elevator — simplifying external track construction. Feeder can be arranged for right- or left-hand discharge. Return chutes are cushioned.

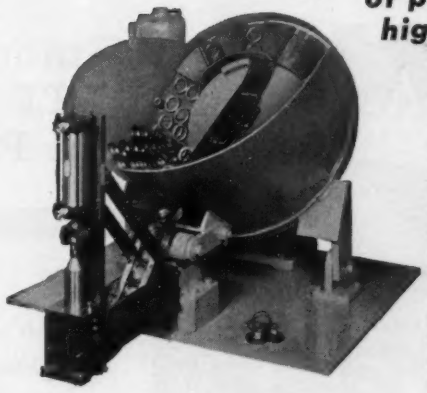
New Bulletin 2812 has full data on DPS elevating feeders. Write for your copy today.

of fragile or finished parts



DPS VIBRATORY FEEDERS are bowl type units that gently handle parts too light or fragile to be handled in rotary type feeders. Through a simple electromagnetic drive, a vibrating action is transmitted to the bowl causing the parts to move up a circular, inclined track. The oriented parts then enter feed tube or discharge track to machining or assembly areas.

of parts for high-production assembly

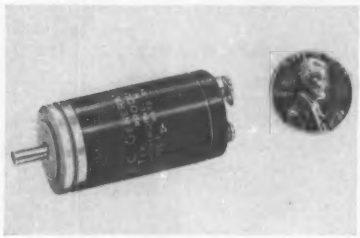


DPS ROTARY FEEDERS employ radially slotted or grooved rotating collector rings. Efficient orienting and feeding of parts is achieved through proper design and engineering of baffle plate, selector guard, feed track, and escapement mechanism. Three different designs are available to meet holding, orienting and feeding requirements. Safety clutch prevents damage to motor or gears in the event of parts jamming.

Detroit Power Screwdriver Company offers industry's most complete line of selective feeders . . . ranging in holding area from 80 cu. in. to 20 cu. ft. For complete details, call your DPS representative or write direct. *Ask for free catalogs!*

DETROIT POWER SCREWDRIVER COMPANY
2801 W. Fort St. • Detroit 16, Michigan
A Subsidiary of Link-Belt Company

Circle 493 on Page 19



same linearity as larger units (1/10 of 1 per cent). Model is available with an output of 3 v per 1000 rpm. **Servo-Tek Products Co.**, 1086 Goffle Rd., Hawthorne, N. J.

Circle 640 on Page 19

Blowout-Proof Gaskets

can be used with all types of ASA flanges

Series 6400 Gask-O-Seals feature safe, blowout-proof, metal-to-metal seals, plus reuseability and ease of installation. They eliminate the need for scraping, cleaning, or refacing flange faces when repairs to lines or equipment are required. Units can be used with almost all types of ASA flanges. Seals are recommended for temperatures from −65 to + 275 F. **Parker Seal Co. Div., Parker-Hannifin Corp.**, 10567 Jefferson Blvd., Culver City, Calif.

Circle 641 on Page 19

Polyolefin Tubing

heat shrinks to form a tight bond

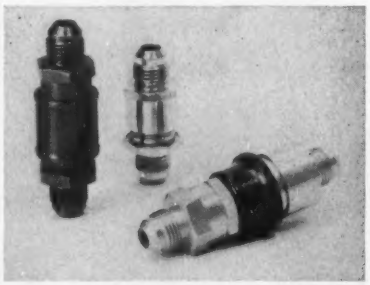
Hyshrink polyolefin tubing and sleeving material heat shrinks in diameter to form a tight bond, even over irregular shapes. Flame retardant and thermally stable, tubing can be slipped easily in its expanded form over terminals, connectors, wire and cable, conduit, and hose. Upon application of 275 F heat, tubing shrinks in diameter to form a strong mechanical bond. Heating does not affect the flexibility of the irradiated tubing, and longitudinal shrinkage is less than 10 per cent. Tubing is an excellent insulating material, with high dielectric and mechanical strength and resistance to most chemicals. It remains flexible and strong from temperatures of 67 to 275 F. Tubing is available in black, white, red, blue, and yellow, in sizes from 0.348 to 0.050 in. ID and in standard lengths of 4 ft. **Anaconda Wire & Cable Co.**, Dept. EFL, 25 Broadway, New York 4, N. Y.

Circle 642 on Page 19

Automatic Couplings

have interchangeable end fittings

Three series of automatic couplings are available for fuel, hydraulic, oil, gases, and other fluid systems. Push-to-engage and pull-to-disengage motion assures reliability, ease of operation, and minimum package dimensions. Units have com-



ARROW AH HART

NOW . . . a more complete line of OIL TIGHT PUSH BUTTONS and Pilot Devices

New Units added to the A-H line

- *Push to Test Pilot Light*
- *Lighted Push Button*
- *Cylinder Lock Push Buttons*
- *Cylinder Lock Selector Switches*

Plus an A-H Exclusive →

Rugged Construction

Dependable Operation

Heavy Duty Push Button Ratings

mon bodies for each flow size, and various end fittings are interchangeable for greater design flexibility. **Exeter Connectors Inc.**, 93 Court St., Exeter, N. H.

Circle 643 on Page 19

Servo Motors

for transistorized amplifiers

RBC2407 servo motors for use with transistorized amplifiers are 115-v, 60-cycle, reversible induction types with high torque-to-inertia ratios. Typical rating is 0.75 oz-in. at 1000 rpm. Gear reductions from 5:1 to 3600:1 are available. Control winding on the motors is split into two sections, each having an impedance of 16 ohms. Each section has separate leads, permitting connection in parallel or in series, with impedances of 8 or 32 ohms, respectively. A center tap between the two sections permits the series connection to be used in push-pull circuits. **Holtzer-Cabot Motor Div., National Pneumatic Co. Inc.**, 125 Amory St., Boston 19, Mass.

Circle 644 on Page 19

Bonding Film

has bond strength to 1000 psi tensile

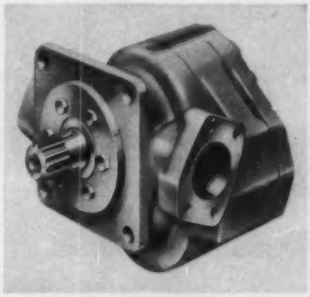
Black adhesive bonding film, Plasmount Hab, is available for permanent attachment of perforated radio control panels, camera parts, plastics, and other applications. Film is rated for attachment of metal, plastics, and vinyls to themselves and other surfaces. A clean, quick bond is secured by heat or solvent attachment at room temperature and with simple manual pressure. Film resists all normal hazards, including temperature extremes from −65 to +250 F. Bond strength is up to 1000 psi tensile. **GP Pre/Set Adhesive Advisory Service**, 102P Hobart St., Hackensack, N. J.

Circle 645 on Page 19

Gear Pumps

in 72, 92, and 112 gpm sizes at 1200 rpm

Series 3600A fluid-power gear pumps assure high volumetric efficiency and reduced frictional losses. Pumps are available in three capacity ratings—72, 92, and 112 gpm at 1200 rpm, 0 psi. They can be operated on most applications at speeds to 2000 rpm and at system



MOTOR CONTROLS

NEW TURN-TO-TEST LIGHTED PUSH BUTTON

Advantages of Push-to-Test Pilot Light and Lighted Push Button in One Unit!

- More Economical Than 2 Units
- Control Circuit Not Energized When Lamp is Tested

FOR COMPLETE INFORMATION . . . write today for your free copy of the Arrow-Hart circular data on these A-H Oil Tight Units and Stations and also on our Standard Duty and Heavy Duty Push Button Lines. The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

- Saves Mounting Space
- Saves Installation Time
- Same Mounting as Other Oil Tight Units

ARROW AH HART

Quality since 1890

MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES • WIRING DEVICES

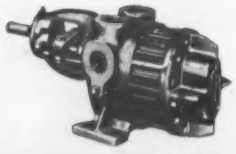
Circle 494 on Page 19

WHATEVER YOUR REQUIREMENTS FOR ROTARY PUMPS, THERE'S A ROPER TO DO THE JOB

Series T .3 to 55 GPM
Choice of 192 Models

Pump and motor units . . . pump serves as end bell of motor. Require minimum space . . . easily installed . . . no coupling required . . . mount in any position. Each unit approximately same size as NEMA motor of HP required for driving. Open drip proof or totally enclosed motors; single or three phase as required.

ROPER
ROTARY PUMPS



Series F 1 to 300 GPM
Pressures to 300 PSI

Feature helical steel pumping gears, hardened steel shafts, bronze flange-type bearings. 4-port design with 8 optional piping arrangements (4 for CW and 4 for CCW rotation) solves installation problems. With or without built-in relief valve in either mechanical seal or packed box construction.

ROPER
ROTARY PUMPS

Series K ¾ to 50 GPM
Pressures to 150 PSI

Extremely compact in all sizes. Helical pumping gears are hardened steel, with steel shafts and bronze bearings. Sizes 10 through 50 GPM have patented venturi suction and discharge principle for smooth flow and quiet operation. With or without built-in relief valve; packed box or mechanical seal.

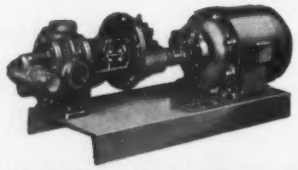
ROPER
ROTARY PUMPS

Series H 5 to 75 GPM
Pressures to 1000 PSI

Designed to operate at direct motor speeds. Used for all types of hydraulic mechanisms where high pressures are required. Hardened steel spur gears for maximum efficiency, and heavy duty roller bearings and bronze wear plates for long life service. Mechanical seal or packed box.

ROPER
ROTARY PUMPS

Series 3600 40 to 300 GPM
Pressures to 100 PSI



Handle thick or thin liquids at slow speeds. Operate in either direction. Hardened iron pumping gears, hardened steel shafts, heavy duty bronze sleeve bearings. Mechanical seal or packed box. Series includes tank truck pumps as well as single motor driven units with gear reduction.

ROPER
ROTARY PUMPS

Send for
"How to Solve Pumping Problems"

Roper Hydraulics, Inc. COMMERCE, GEORGIA
Manufacturers of Standard, Special and Custom Pumps for All Industries

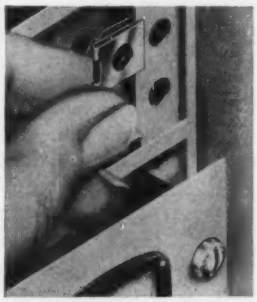
pressures to 1500 psi. Pumps are particularly suited for applications on high-capacity earth-moving and materials-handling machinery, or on similar mobile equipment. **Hydreco Div., New York Air Brake Co.**, 9000 E. Michigan Ave., Kalamazoo, Mich.

Circle 646 on Page 19

Clip-On Receptacles

for use with
Lion No. 2 fasteners

Made of hardened steel, cadmium-plated, clip-on receptacle slips on over a punched or drilled hole and locks securely in place. Riveting or welding is eliminated, and installation is accomplished in seconds. Where prepunched channels are



used, clip-on receptacles can be moved easily from hole to hole to adjust for units of various sizes. Clip-on receptacles are easily removed. Clip accommodates frame thicknesses of 0.055 to 0.090 in. **Southco Div., South Chester Corp.**, Industrial Highway, Lester, Pa.

Circle 647 on Page 19

Indicator Lights

have spring-mounted
rotatable lenses

Data Cap assemblies offer two new features: A lens cap with a colored cylindrical lens on which a legend may be hot stamped; a clear lamp cartridge without a legend. Should the cartridge burn out, it can be replaced quickly from front of panel. Lens cap and lamp cartridge are assembled with lampholder to make the complete unit. Lamp cartridge plugs into the base, and lens cap screws onto the bushing of the lampholder. Lens is spring-mounted and rotatable, facilitating alignment of the legend after installation of the

Circle 495 on Page 19

MODERN EQUIPMENT PRODUCES *Quality Aluminum*

Inside QSM's new cast house the most advanced equipment and metallurgical techniques have been combined to produce aluminum alloy rolling ingots of exceptional quality.

For productive efficiency two custom-built Swindell-Dressler melting furnaces have been set up with two companion holding furnaces in tandem. Molten metal is transferred directly from melting to holding furnaces after the industry's most modern fluxing has been completed.

As a final assurance of top quality, the melt is held in a "tranquil bath" until filtered at a controlled rate through glass cloth screening into the molds.

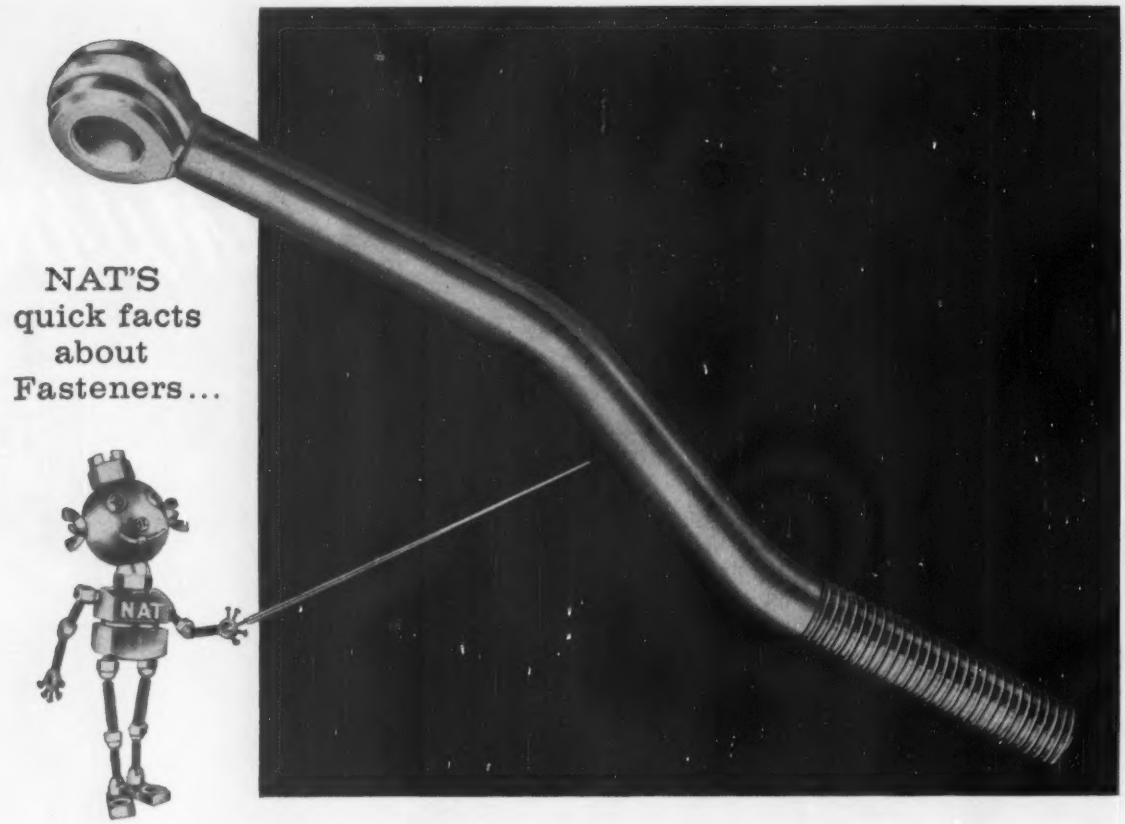
The resulting ingots will meet QSM's exacting standards and insure you of quality aluminum sheet and coil.

QUAKER STATE METALS CO. • LANCASTER, PA.

A Division of HOWE SOUND COMPANY

Mill Producers of Aluminum Sheet and Coil

Circle 496 on Page 19



Shining example...of big things in **specials** by National

This is a large offset eyebolt, shown here big as life. We designed and made it to order for one of our customers.

To begin with, it shows that we can and do make some sizable things in the way of cold headed Special Products.

But there's more here than seems to meet the eye.

When our customer brought us this eyebolt, he had been having it made as a forged eye welded to a machined bolt, with a cut thread.

We gave it some thought, then made it... with a difference. We cold formed it in one piece, and rolled the thread... turning out a stronger, more practical, and more efficient part, and lopping off costs all along the line.

And there's the real point... what we really mean when we mention doing BIG things in Specials, at National... better parts, large or small, at lower cost, by cold heading and designing for profit.

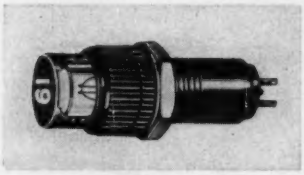
We do it right along, and we can very likely do it for you, too. Want to find out? Just drop a note to Special Products Service, at our address*. And if you just happen to have a Special problem, tell us all about it—and let us help.

*It will bring you this illustrated booklet "Bring your Special Problems to National", 16 pages about Specials as National sees them.

National PRODUCTS

The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California



assembly. Cylindrical lens is 0.425-in. in diam and accommodates up to three hot-stamped digits, symbols, or letters. Seven lens colors are available. Lights are about 1⅝ in. long, over-all, and mount in ⅜-in diam clearance hole. **Dialight Corp.**, 60 Stewart Ave., Brooklyn 37, N. Y.

Circle 648 on Page 19

High-Temperature Solenoid

withstands temperatures to 1600 F

Hermetically sealed solenoid, rated for twice the life of previous models, has a protective coating which helps achieve a life rating of 1000 hr at 1000 F and will withstand up to 1600 F. Plunger travel is 0.020 in., and weight of the unit is 0.28 lb. Conduit is available in two styles, rigid for increased reliability or flexible for compactness

and installation ease in crowded spaces. Solenoid can be used with electromechanical units to operate at temperatures previously nonaccessible to certain types of equipment. **Aircraft & Missile Products Div., Barber-Colman Co.**, Rockford, Ill.

Circle 649 on Page 19

Flow-Control Valve

uses no poppets or spools

In new Tube-O-Matic valve, squeeze action automatically controls the flow of air, oil, chemicals, and grinding slurries without the use of pop-

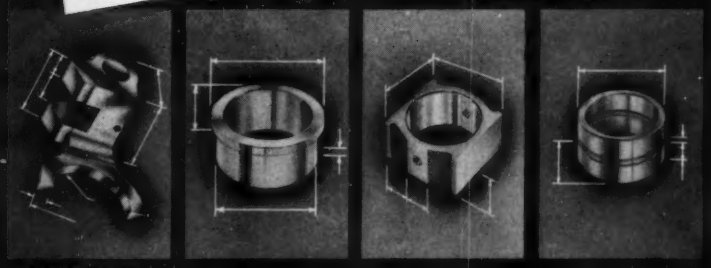
(Please turn to Page 186)

BUNTING® BEARINGS

engineering for **both** cost and mechanical requirements in the bearing field . . .

Bunting can help you identify and procure the bearing or part that will do your job at the lowest possible cost. Often a re-examination of the actual mechanical needs of a bearing application reveals an opportunity to save money in design. Another saving is almost invariably achieved by considering ALL the new bearing materials which Bunting makes available to you today. Let Bunting help you engineer your bearing application in the light of modern availabilities. Send in your blueprints or ask for engineering counsel.

. . . case in point *



*Clearly evident is the economy in the production of this shifter fork by Bunting Powder Metallurgy. The elimination of practically all machine work effects striking cost reduction.

*This cylinder gland bearing made of Bunting Bearing Aluminum is an example of how to save weight and money on the cost of large, thick-wall bearings and parts.

*This cast bronze cam block, made to unusually close limits with very fine finish, is absolutely round and true to size with cost at a feasible figure.

*Solid cast aluminum gear bearing to replace roller bearing for longer life and lower cost.

BUNTING ENGINEERS . . . Bunting maintains a staff of bearing engineers whose wide experience and specialized knowledge are available to you gratis for study and recommendation concerning your current or contemplated bearing applications.

write for these . . .

No. 158 General Catalog—Complete listings of Cast Bronze and Sintered Bronze Stock Bearings and Bars and Bunting Bearing Aluminum Bars. Pocket size edition.

No. 1 Engineering Handbook of Powder Metallurgy—A comprehensive technical treatment of engineering and manufacturing of sintered metals, bearings and parts.

No. 46 Technology of Bunting Bearing Aluminum—A technical treatise on the composition of and machining Bunting Bearing Aluminum Bar Stock.

The BUNTING Brass and Bronze Company
Toledo 1, Ohio, Phone EVergreen 2-3451

BEARINGS, BUSHINGS, BARS & SPECIAL PARTS OF CAST BRONZE SINTERED METALS OR ALUMINUM ALLOYS

Circle 498 on Page 19

HIGH STRENGTH FORMICA®
FORMICA®
Laminated Plastic
subsidiary of CYANAMID

save more with parts that do more

THERMOSETTING MOLDED PLASTIC PARTS

Save on Sub-assembly. Here's how: by combining several properties and functions, one Formica molded part frequently replaces two or three made of ordinary materials. And by molding laminated and macerated plastic materials together, with one or more metal inserts, the Formica part becomes a *component* that's far more useful than conventional parts.

Save on Material. Formica's unique strength/weight ratio helps you improve product performance and save on direct material costs, too. It's strong as steel, has excellent impact and flexural strength, plus good electrical insulating and corrosion resisting properties. It's lighter in weight and costs about the same per pound, so you can buy several Formica molded parts for less than one comparable metal part.

Save on Replacement, too, because lighter weight means reduced wear, longer part life. And remember, molding uniformity eliminates costly machining.

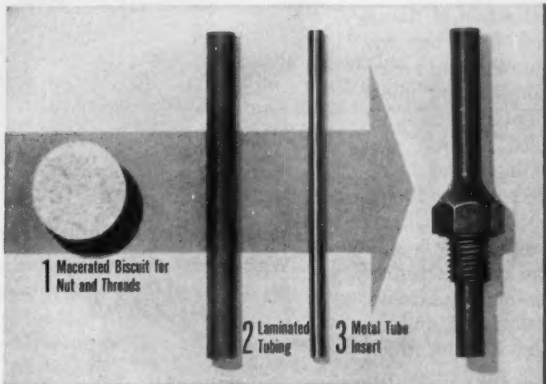
Get complete information on how Formica molded parts are tailor-made to give you exactly the right formulation of properties, functions, size, shape and finish. Use coupon below to request your free copy of bulletin 909.

FORMICA HIGH IMPACT THERMOSETTING PLASTIC PARTS COMPRESSION AND TRANSFER MOLDED

PROPERTIES	RANGE
Izod impact, ft. lbs. per in of notch	0.65 to 12.0
Dielectric strength, 1/8" perpendicular, short time, vpm	210 to 750
Flexural strength, flatwise, psi	8,000 to 25,000
Compressive strength, psi	18,000 to 35,000
Moisture absorption, 2" diameter disc (ASTM D570—57), percent	0.15 to 2.2
Chemical resistance	Resistant to mild solutions of acids and alkalies
Finishes	Sanded to mirror-smooth

BASIC FORMS—Laminated, macerated or laminated-macerated parts, compression or transfer molded, of paper, glass, canvas and asbestos cloth fillers, impregnated with phenolic, melamine, silicone, D.A.P. and epoxy resins.

APPLICATIONS—For electrical, mechanical and chemical applications in a wide range of industries including textiles, aviation, missiles, electrical/electronic, appliances, automotive, chemical, machinery, materials handling and many others.



BUILD-UP FOR SAVINGS—Formica molds laminated and macerated forms with metal tube insert to produce another do-more, save-more part. This light bulb frosting nozzle features chemical and moisture resistant properties for superior acid-carrying performance. Combining nut, thread and metal tube insert into one unit saves costly assembly and machining time.

FORMICA CORPORATION
4514 M Spring Grove Avenue
Cincinnati 32, Ohio

☐ Send free copy of Molded Products Bulletin 909.

NAME_____

COMPANY_____ TITLE_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

FI-2509

Circle 500 on Page 19

63 SIZES
READY TO SHIP

centrifugally cast

Stainless Steel

SLEEVES • LINERS
CORED BAR STOCK

In a rush? Order from Vollrath for immediate off-the-shelf shipment. All 13¼" long, Semi-machined to 1/16" of sizes listed. Uniform quality.

TYPES 304 and 316

O.D.	I.D.	O.D.	I.D.	O.D.	I.D.
2½	x 2	4	x 2	4½	x 3½
2¾	x 2		x 2¼		x 3¾
	x 2¼		x 2½		x 4
3	x 2		x 2¾	4¾	x 2¼
	x 2¼		x 3		x 2½
	x 2½		x 3¼		x 2¾
3¼	x 2		x 3½		x 3
	x 2¼	4¼	x 2		x 3¼
	x 2½		x 2¼		x 3½
	x 2¾		x 2½		x 3¾
3½	x 2		x 2¾		x 4
	x 2¼		x 3		x 4¼
	x 2½		x 3¼	5	x 2½
	x 2¾		x 3½		x 2¾
	x 3		x 3¾		x 3
3¾	x 2	4½	x 2		x 3¼
	x 2¼		x 2¼		x 3½
	x 2½		x 2½		x 3¾
	x 2¾		x 2¾		x 4
	x 3		x 3		x 4¼
	x 3¼		x 3¼		x 4½

PHONE • WIRE • WRITE

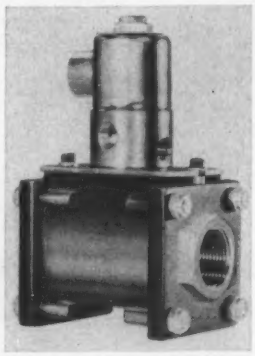
the **Vollrath** Co.

FOUNDRY DIVISION
Dept. MD, Sheboygan, Wis.

Circle 501 on Page 19

(*Continued from Page 183*)

pets or spools. There are no metal-to-metal contacts and no metal-to-rubber seals. When valve is open, supply pressure through the inlet port forces an elastic rubber sleeve against the tube, forcing media to flow around the inlet plug and through the outlet port. To close the valve, pilot pressure is applied between the ID of the tube and the outer periphery of the rubber sleeve. This collapses the sleeve over the rounded ends of the inlet and outlet end plugs, sealing off supply



pressure. Only action is the flexing of the sleeve. Pressures to 200 psi can be handled. Pipe sizes range from ¼ to 12 in. **Airmatic Valve Inc.**, 7313 Associate Ave., Cleveland 9, Ohio.

Circle 650 on Page 19

Vulcanized Fiber

flame-resistant material has high dielectric strength

Pyronil E electrical grade of flame-resistant vulcanized fiber has improved dielectric strength and arc resistance. Rated non-burning under ASTM procedures D-635 and D-568, material is intended for use as a combination flame, heat, and dielectric barrier in electrical and electronic equipment. Low initial cost and ease of fabrication make it suitable for use in the manufacture of data-processing equipment, business machines, radio, television, and appliances. Fiber in 1/32-in. thickness has a dielectric strength of 215 volts per mil under ASTM test method D-149 and arc resistance of 50 seconds under ASTM test method D 495. Gray in color, material is available in rolls, coils, or sheets in thicknesses of 0.010 to

we see

EYE TO EYE

when it comes to sealing service . . .

YOU WANT

- lowest original cost compatible with dependable service
- a sealing service with the least maintenance cost
- long term sealing with the very minimum "down time"
- a line of mechanical seals designed to meet the widest range of applications

WE WANT

- the opportunity of showing you that this, *and more*, is yours when you meet your sealing needs with . . .

DURA SEAL

"The Engineered Mechanical Seal"

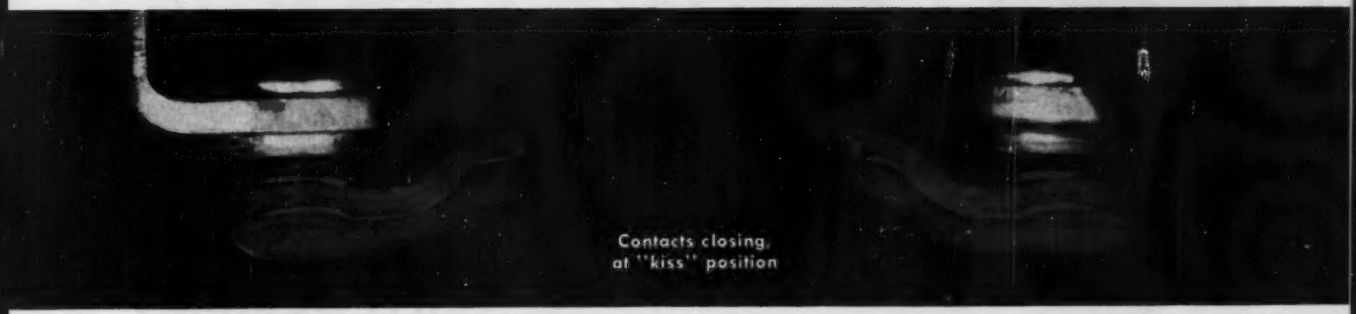
We suggest you write us today for a copy of Dura Seal catalog No. 480 MD

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Circle 502 on Page 19

Contacts open



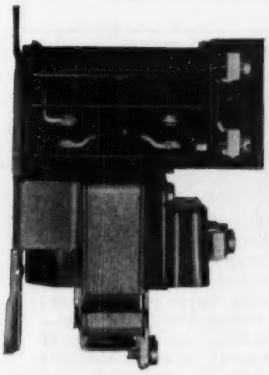
Contacts closing, at "kiss" position

Contacts close with "wipe and roll" action

How a General Electric CR2810 machine tool relay had . . .

20 MILLION CHANCES TO FAIL

BUT DIDN'T



MORE THAN 20 MILLION TIMES a large automotive body stamping company challenged the General Electric CR2810 machine tool relay to "make" and "break."

It was part of an accelerated life test conducted recently in their own plant to find the most reliable machine tool relay for their continuous production line.

Long after all competitive relays tested had failed, the contacts in the G-E relay were still "making" and "breaking" with continuous reliability. Why? Greater fidelity—made possible by the smooth "wipe and roll" action of the General Electric relay contacts.

OTHER ORIGINAL EQUIPMENT MANUFACTURERS as well as users have proved to themselves the reliability of General Electric relays. For example, after one year's experience with G-E relays, a manufacturer of packaging machinery cut his purchases almost in half. His explanation: "Before I bought General Electric relays, 50 per cent of my purchases were used to replace relays under my maintenance contract." He saved inventory investment and stocking costs. You can too.

Extra reliability is one of the "measurable advantages" of G-E machine tool relays that builds customer acceptance for your products. Add to this the ease of mounting and wiring, the compact design, and the circuit flexibility of G-E relays, and you have a value that can't be matched.

Why not test them yourself? Call your G-E sales engineer at your nearby G-E apparatus sales office. Ask for bulletin GEA-7021. General Electric Company, Schenectady 5, N. Y.

811-13

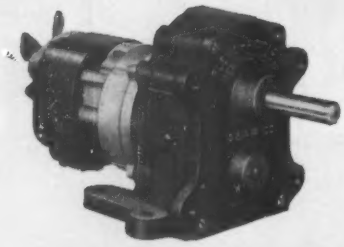
You get **MEASURABLE ADVANTAGES**
with General Electric Control

Progress Is Our Most Important Product

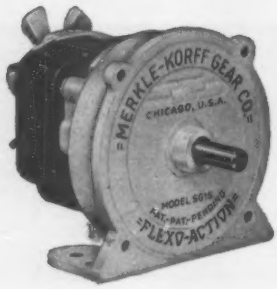
GENERAL ELECTRIC

Circle 503 on Page 19

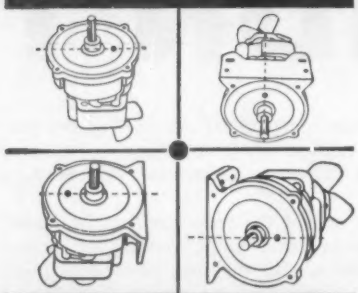
MORE POWER
IN LESS SPACE



MORE TORQUE
PER POUND



LOWER COST
PER LB.-IN.
OF TORQUE



MOUNTINGS TO FIT EVERY NEED
All motor types. RPM from fractional to 800. Torques from 300 lb.-in. to 4. Rugged, long life, precision hobbed gearing.

WRITE TODAY!
Our design engineers will be pleased to help you solve your application problems.

MERKLE—KORFF
MK
MOTIONDISERS
MERKLE-KORFF GEAR CO.
Dept. 215
215 North Morgan Street
Chicago 7, Illinois
MOnroe 6-1900

Circle 504 on Page 19

1/16 in. National Vulcanized Fibre Co., 1060 Beech St., Wilmington, Del.

Circle 651 on Page 19

Knobs and Wheels

have tapped plastic threads

Tapped plastic threads instead of threaded-metal inserts are available in a variety of knobs and handwheels. In cases where knob or wheel is removed from its shaft infrequently or not at all, plastic threads are practical and economical. Dimco-Gray Co., 207 E. Sixth St., Dayton 2, Ohio.

Circle 652 on Page 19

Clutch-Potentiometer

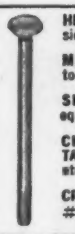
resists shock and acceleration of 100 g

New combination consists of a clutch-brake unit with a special end cap that becomes the potentiometer mounting plate and part of the housing. Complete assembly is a single, permanently sealed unit with a common shaft and integral bearings. Since this clutch-pot potentiometer is a single unit, problems of coupling backlash, shaft misalignment, end play, and excessive bearing drag are eliminated. Output shaft of the clutch-brake unit is the rotating shaft of the potentiometer upon which is assembled the wiper arm of the pot. Elimi-

*Savings like this deserve a closer look

COLD HEADING
SAVES OVER
300%
ON THIS TERMINAL POST

Due to the many technical problems involved, only Hubbell was willing to tackle this job. The result: big savings in production costs, greater uniformity, and faster delivery. This is just one more example of Hubbell's ability to solve tough and unusual cold heading problems.

Original Screw Machined Part	Same Part Re-designed for Hubbell Cold Heading
	 HEAD INDENTED to fill out sides, make corners sharp MINIMUM FILLET under head to permit close seating SHANK EXTRUDED due to equal dia. of shank and thread CLOSE TOLERANCE MAINTAINED on length and diameter CRITICAL FIT . . . to class #2 specifications

*A closer look at your fastener requirements may reveal some that lend themselves to the economies of Hubbell cold heading. If so, investigate! Send us samples or blueprints of the parts for analysis and estimate. No obligation.

HARVEY
HUBBELL
INCORPORATED
Machine Screw Department Bridgeport 2, Connecticut

Circle 505 on Page 19

if your twin problems are

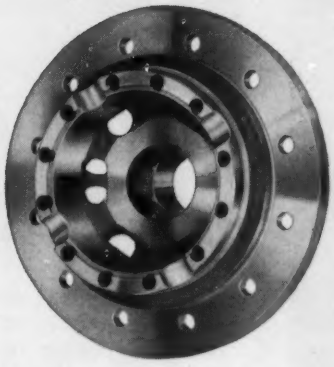
product improvement

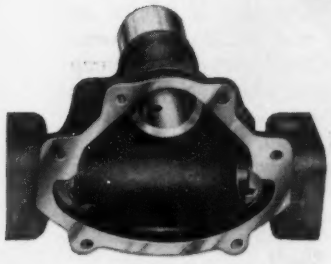
and

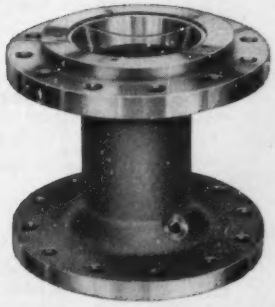
cost reduction

NATIONAL HTM CASTINGS

are the answer







HTM is strength . . . toughness . . . wear and fatigue resistance . . . non-seizing. HTM is higher machinability than B1112 steel . . . it's closer as-cast tolerances that can reduce or wipe out machining operations.

If you're reappraising your product from a competitive point of view . . . if you're looking for production economies—look into HTM castings. Yes, HTM is many things—and it's just made to order for many mass-produced products just like yours.

A-1151A

HTM (Pearlitic Malleable) is many things—and they all add up to a *better product at lower finished cost.*

NATIONAL MALLEABLE and STEEL **CASTINGS COMPANY**

Established 1868 *Cleveland 6, Ohio*

MEMBER MALLEABLE CASTINGS COUNCIL

The nation's largest independent producer of malleable and pearlitic malleable

Circle 506 on Page 19

FELT
BY FELTERS

PROVIDES DEPENDABLE,
LOW-COST PARTS FOR

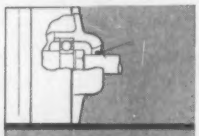
ELECTRIC MOTORS

Seals . . . wicks . . . lubricators . . . washers . . . gaskets — are all vital electric motor parts that benefit from Felt by Felters.

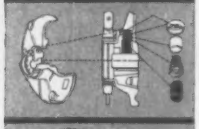
A special Felters' "Engineered Fabrication" processes felt to specific thickness, density, hardness, and resiliency; and provides special characteristics such as absorption, stiffness, water repellency and flameproofing.

And, new felt and plastic laminates, called PlastiFelts, use synthetics such as Nylon, Teflon, Hycar and rubber to provide an even wider range of application, plus greatly improved performance.

These are some of the many electric motor applications where Felt by Felters offers both a low-cost and high performance material for non-metallic parts.

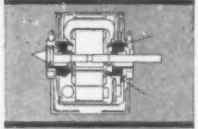


Felt seal inserted around shaft opening retains grease and keeps out foreign matter.

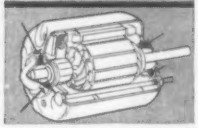


This self-oiler uses a felt wick, bearing against the shaft under spring pressure, for constant lubrication.

This is a thrust washer designed for double duty as a lubricator by the use of a felt ring and lubricating notches.



Lifetime bearing lubrication is possible by selection of correct SAE grade, and designing into sealed bearing.



Felters' "Engineered Fabrication" makes it possible to specify felt shapes for a complete motor and shaft lubricating system, combining reservoirs, and wicking, and directing oil flow to all required areas.

To get the most out of Felt, send for the Felters Design Book — a complete digest on properties and applications. Write, today.

Ask for **FELT** *from . . .*

The **FELTERS** Co.

271 SOUTH STREET
BOSTON 11, MASSACHUSETTS

Pioneer Producers of Felt and Synthetic Non-Woven Fabrics

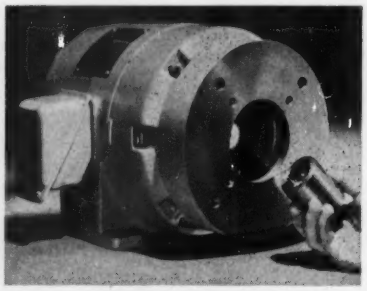
nation of the coupling has also allowed the use of smaller masses in this unit, which makes the entire assembly less susceptible to the forces of high loads. Shock and acceleration forces in excess of 100 g have no effect on the performance of these units. **Autotronics Inc.**, Dept. 28, P.O. Box 208, Florissant, Mo.

Circle 653 on Page 19

Hydraulic Pump Motors

are furnished with coupling

Tri/Clad 55 spline-coupled hydraulic pump motors are available in NEMA frame sizes 182, 184, 213, and 215. Motors are almost 3 in. shorter than those in the present open-adapter design. Pump



motors are furnished with the coupling, eliminating the need for selection and assembly of a separate coupling. Coupling is splined on the motor end and has a conventional bore and keyway on the pump end. Motors, which accept a wide variety of pump designs, are available in 1-5 hp. **General Electric Co.**, Schenectady 5, N. Y.

Circle 654 on Page 19

Flexible Shaft

has built-in quick-disconnect coupling

HD quick-disconnect flexible shaft has built-in high-speed ball bearings at each end and couplings that can be bored to suit and attached with set screws. Quick disconnect makes shaft suitable for applications requiring a portable source of power than can be connected and disconnected very fast. Shaft is available in $\frac{3}{8}$, $\frac{1}{2}$ or $\frac{5}{8}$-in. core, having a maximum torque capacity of 220 lb-in. Core is made of layers of

Circle 507 on Page 19

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 "V" Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

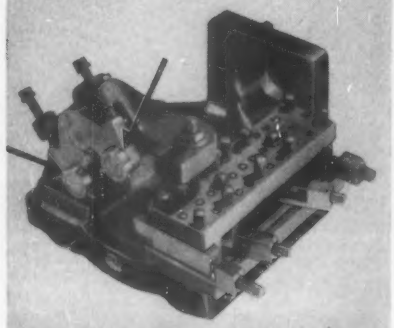
Circle 508 on Page 19

McGILL® CAMROL® BEARINGS

are proven performers—with cost and assembly advantages

McGILL CAMROL bearings have rolled up an unequalled 25-year history of high performance and dependability — with the cost savings of standard bearings over built up shaft and roller units. They eliminate the time-consuming intricacies of procurement and assembly of parts for improvised bolt, bearing and washer followers. You, too, can rely on the designed-in ability of CAMROL bearings to accept intermittent shock and fluctuating heavy loading coincident to cam action, track or guide and support applications. CAMROL bearings are built for stock in roller diameters from ½" to 4" in the CF series with integral stud and the CYR series for shaft mounting. Both types are available with or without positive, integral seals for retention of prelubrication and protection against contaminants. Following are typical applications.

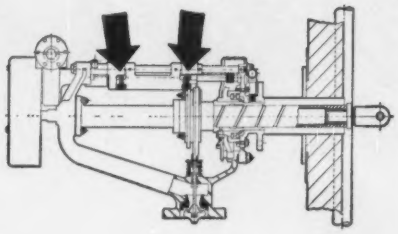
GISHOLT MACHINE COMPANY incorporates McGILL CAMROL® bearing accuracy into tooling set-ups

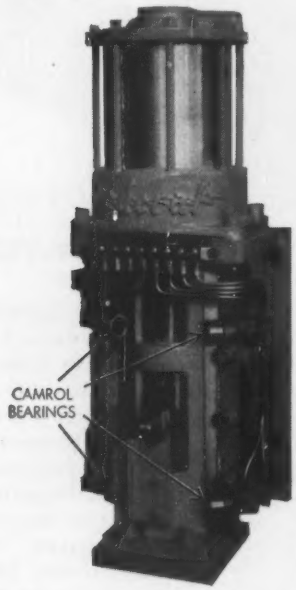


Gisholt Machine Company takes advantage of the cost and performance features of CAMROL CF series bearings, (with integral stud), on a group of standard bar tools for mounting on the turrets of Gisholt Masterline Turret Lathes. A representative tool of this group is the Multiple Cutter Turner shown.

CF CAMROL® bearings provide rolling contact in automatic soot blowers

Diamond Power Specialty Corporation has incorporated McGILL CAMROL bearings into the design of their Model IR Short Retraction blowers to produce a smooth rolling contact between cam flange and latch bar. This equipment is used for cleaning water cooled furnace walls, hopper slopes or narrow portions of tube banks adjacent to walls automatically.





FEDERAL MACHINE and WELDER COMPANY puts McGILL uniform quality into welding equipment

The anti-friction welder head unit, shown, is one of the several applications of McGILL CF CAMROL bearings in Federal Machine and Welder Co. equipment. CAMROL bearings are used in weld heads, transfer slides and various other uses where a precision, smooth, uniform movement is desired. Low cost, uniform quality, excellent performance and exceptional length of life are benefits gained in eleven years of use of CAMROL bearings.

Both the regular CF Series and the prelubricated and sealed SCF Series CAMROL bearings are used in Federal equipment.

engineered electrical products

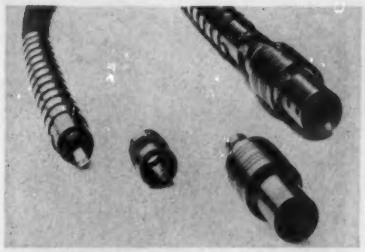
McGILL®

precision needle roller bearings

Send for free copy of McGILL Bearing Catalog No. 52-A.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana



music wire assembled especially for high-speed operation and long life. The casing is lined with oil-tempered spring steel, reinforced with wire braid, covered with oil resistant neoprene-impregnated fabric, and an abrasion-resistant rubber jacket. Stow Mfg. Co., 11 Shear St., Binghamton, N. Y.

Circle 655 on Page 19

Dry-Film Lubricant

has low coefficient of friction

Drilube 816 is a molybdemum disulfide and graphite, epoxy-resin catalyzed system. Equal amounts of resin and hardener are mixed to provide an outstanding resin-bonded, dry-film lubricant. Material operates continuously at temperatures from −100 to +725 F with a coefficient of 0.035. **Drilube Co.**, 723 W. Broadway, Glendale 4, Calif.

Circle 656 on Page 19

Limit Switch

for use in highly repetitive applications

Magnet operated limit switch for use in applications of a highly repetitive nature is designed for operation without physical contact of levers, rods, or shafts. It is for use where long life and high reliability are important. Designated CR115A19, magnet-operated switch is available with contact ratings of

NEEDED: VIBRATION ISOLATION AT BOTH HIGH AND LOW FREQUENCIES

A mount soft enough to isolate vibration in the upper range of frequencies generally gives trouble with a low natural frequency. With sensitive precision equipment, such as airborne sighting mechanisms, for example, a mount must work at *both* ends of the frequency spectrum.

ANSWER: MB ISO-DAMP (tm) MOUNTS CONTROL FULL FREQUENCY RANGE

Resilient rubber sections with equal spring rates in all directions (an original MB mount principle) give the MB Isomode Mount its high frequency isolation efficiency in any position. In the low range, a unique damping mechanism effectively restricts resonant build-up; does not affect high frequency isolation. Unit also meets MIL-E-5272-A shock requirements.

WHAT'S YOUR MOUNT PROBLEM?

Iso-Damp mounts can be modified to meet your particular requirements. Or possibly one of MB's other standard mounts may be the answer to your special vibration control problem. Why not let MB's experienced specialists help find the right answer for you. Write us for complete information—ask for Bulletin 418-4.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.
1056 State Street, New Haven 11, Conn.

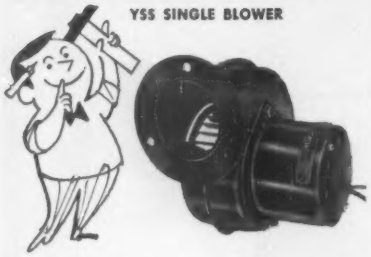
Circle 510 on Page 19

put HEINZE in your designs

YSD DOUBLE BLOWER

YS BLOWERS

YSS SINGLE BLOWER



MINIMIZE AIR NOISE

ASSURE LONG BEARING LIFE

Large (3⅝ in.) balanced air rotors, powered by a slow-speed 4 pole shaded pole induction motor, assure quiet operation and long bearing life. Blowers are enclosed in durable metal housing. YSS Single Blower delivers 50 cfm at 1650 rpm; YSD Double Blower delivers 100 cfm. Standard units operate on 115V, AC, 60 cycle. Other voltages and frequencies are available.

Applications include photographic dark rooms; laboratories; cooling of electronic tubes; kitchens; refrigeration and air conditioning units; vending machines; and similar uses.

Send coupon for technical data on the complete line of Heinze Sub-Fractional Horsepower Motors and Blowers.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

Heinze Electric Company, Dep't MD
685 Lawrence St., Lowell, Mass.

Please send me technical literature and price information on Heinze Motors and Blowers.

Name & Title_____

Company_____

Street & No._____

City & State_____

Circle 511 on Page 19

0.75 amp make, 0.2 amp carry and break at 115 v ac. Response time is 0.001 sec. General Electric Co., Schenectady 5, N. Y.

Circle 657 on Page 19

Solenoid Valves

are cool and quiet operating

Cooler coils and quieter operation in solenoid valves are available for reliable flow control in vending machines, electrical appliances, oil burners, pneumatic instruments, and industrial process controls. Long mechanical life is made possible by design improvements that have reduced valve noise and coil heat rise. Normally open or normally closed, valves are available in two and three-way types for ac and dc operation. Maximum pressure range of the new two-way, ac, normally-closed valves is 0 to 400 psi. Two-piece construction of plunger-guide assembly permits extremely accurate alignment of the plunger for accurate control and quiet operation. Valve bodies and all internal parts are corrosion resistant. Valves can be serviced without removing them from the line. Allied Control Co. Inc., 2 East End Ave., New York 21, N. Y.

Circle 658 on Page 19

Precision Potentiometer

permits changing of settings in 30 sec

Series P32 Protractatap potentiometer permits changing of settings by eye, using only a pencil point, in 30 sec. Taps can be set to ½ deg. Resistance range is 5000 to 250,000 ±5 per cent, and linearity

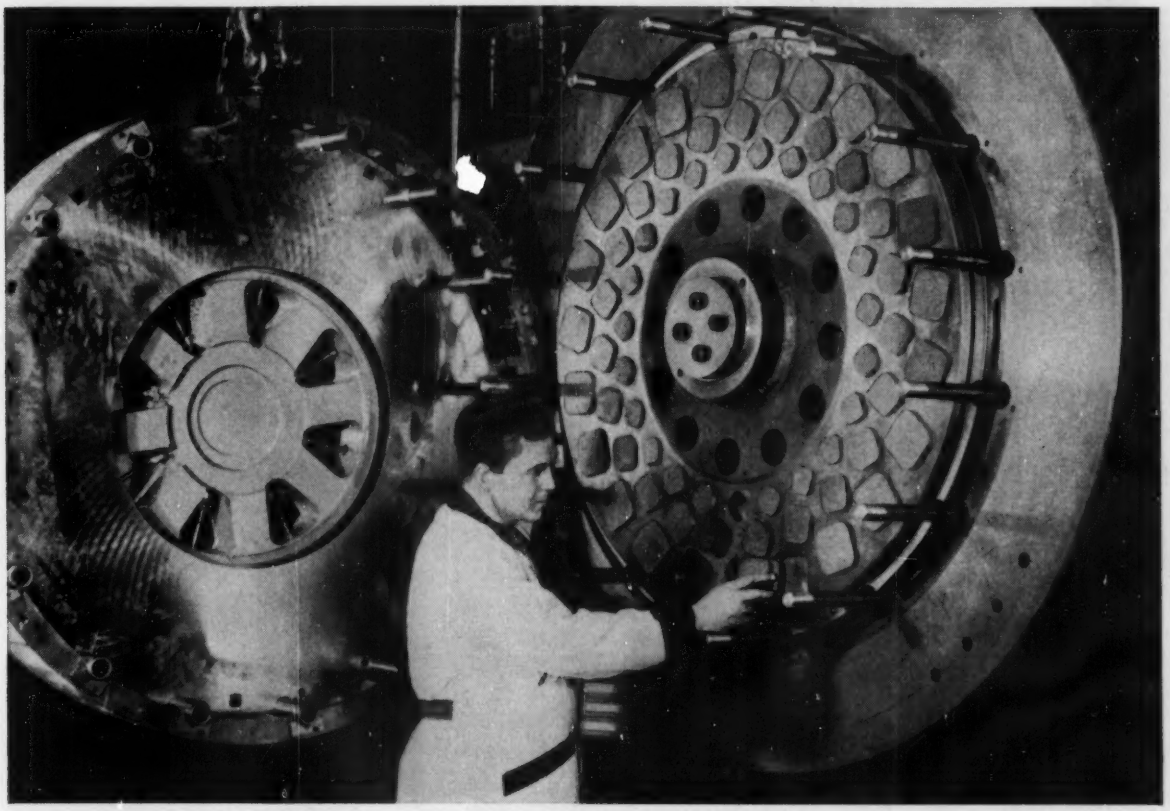
MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989

Circle 512 on Page 19



Unique R/M friction blocks float free in this clutch lining retainer of the air clutch and brake on a giant 4000-ton Danly press.

How R/M friction blocks with special structural core licked high shear and abrasion

Engineers of Danly Machine Specialties, Inc., Chicago, and friction specialists of Raybestos-Manhattan collaborated in the development of a special "core-type" free-floating friction block to solve a problem involving high shear forces and abrasion.

Design reduces inertia

Danly's exclusive air clutch and brake used on mechanical presses from 25- to 4000-ton capacity greatly reduces start and stop inertia, with corresponding reduction of wear on friction surfaces. The standard design employs blocks of solid friction materials. These blocks float freely in openings in the clutch and brake lining carriers.

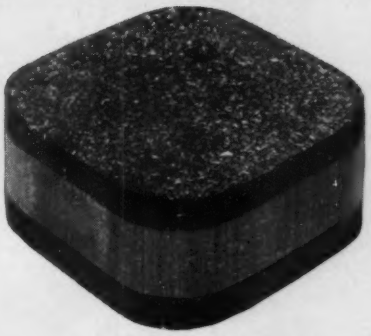
For severe service applications it was necessary to find a material which would stand the high shear and compressive forces at the points where the friction material was supported in the steel carrier.

The problem was solved by the development and application of a special high structural strength organic core (Pyrotex) to combat shear and abrasion. The ¾-in. core is sandwiched between two 3/16-in.-thick facings of asbestos friction material which gives high impact strength, excellent wear resistance, and is non-abrasive. It also has high compressive and shear strength with high-temperature stability.

This is another example of R/M's ability to adapt proven friction materials for special shockloading, stress or wear applications. Only R/M manufactures *all types of friction materials —your assurance of sound, unbiased advice on the material best suited to your application.*

Experience, service

To take advantage of R/M's more than 50 years of friction experience and its outstanding service—just phone or write. A sales engineer can be at your desk within 24 hours.



Special friction block—Two 3/16-in.-thick facings of asbestos friction material are bonded to a ¾-in. *Pyrotex* structural core.

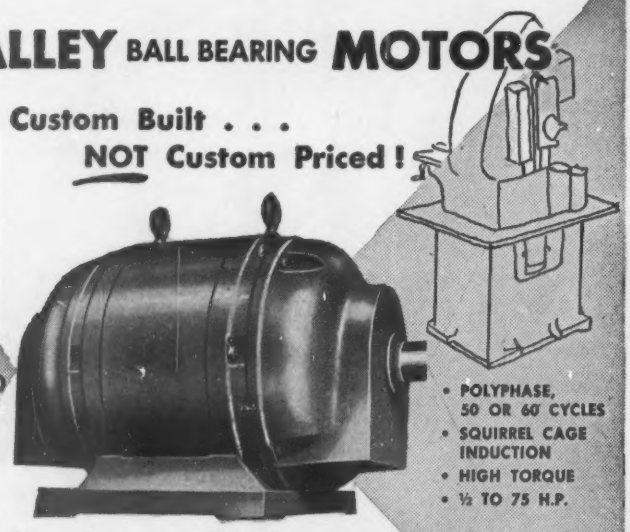
You will find this R/M Bulletin 501 packed with useful engineering data on friction materials. Why not write for it today —no obligation.

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION: Bridgeport, Conn. • Chicago 31 • Cleveland 16 • Detroit 2 • Los Angeles 58

VALLEY BALL BEARING MOTORS

Custom Built . . .
NOT Custom Priced!



AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

Cool Running . . . Continuous Service . . .

that's the axiom Valley Motors live up to.
They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

VALLEY
ELECTRIC CORPORATION
4221 Forest Park Blvd. • St. Louis 8, Mo.

Circle 514 on Page 19

K & T'S MILWAUKEE-MATIC
TAPE-CONTROLLED MACHINING CENTER
FEATURES BEAVER BALL SCREWS
ON ALL 3 AXES!

A significant machine tool achievement—Milwaukee-matic numerically controls positioning, tool selection, indexing, machining, speeds and feeds. Preloaded Beaver Ball Screws with the inherent precision, essential in data control, were the choice of Kearney & Trecker designers for spindle positioning, cross feed and table feed—just as they are with most builders of numerically controlled machines.

Our engineers will be glad to work with you.

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 515 on Page 19

is ± 0.25 per cent. Protractor has 1-deg divisions, with every 10 deg labeled. Servo or clamp-ring mountings are available. **Accuracy Inc.**, 4 Gordon St., Waltham 54, Mass.

Circle 659 on Page 19

Protective Film

prevents corrosion of metal surfaces

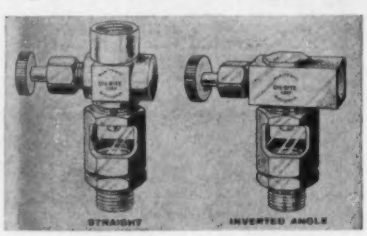
Long-term protective coating, Soft-Seal, prevents corrosion of metals in production processes, storage, and shipment. It penetrates grain boundaries, cracks, and pores to form a continuous protective film from 1 to 8 microns thick, and is applied by spray or immersion. Material is equally effective on iron, steel, aluminum, magnesium, and plated finishes. Length of time Soft-Seal remains effective varies with the conditions of exposure. **Corrosion Reaction Consultants**, 116 Chestnut St., Philadelphia 6, Pa.

Circle 660 on Page 19

Sight Feed Valves

have excellent flow characteristics

Heavy-duty sight feed valves control the dispensing of a liquid volume and visually indicate its flow in a sight chamber. Flow volume is adjusted by a needle valve. Redesigned models are available in angle, cross, inverted-angle, and



BEAVER
BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •

Beaver Precision Products INC.
CLAWSON, MICH.

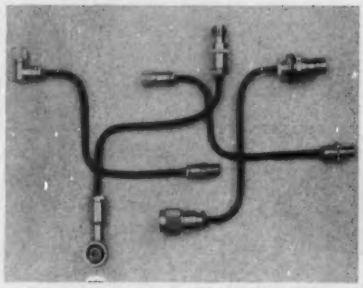
Circle 515 on Page 19

straight patterns. Orifice has been enlarged, permitting higher flow rates. Larger sight permits better viewing of liquid flow. Swivel arrangement is also incorporated into most models, allowing viewing windows to be turned to any direction. Valves have excellent flow characteristics with low pressure drop. Needle valve controls and regulates liquid flow from full flow to complete shut off. Valves are for ¼, ⅜, and ½-in. pipe threads. **Oil-Rite Corp.**, 2376 Waldo Blvd., Manitowoc, Wis.

Circle 661 on Page 19

Semirigid Connectors

feature Collett clamp construction



New TNC Coaxitude semirigid connectors feature Collett clamp construction so cables cannot turn or pull out. Miniaturized versions are also available for use where size and weight are considerations. Units operate in temperatures from −65 to +260 F. **General RF Fittings Inc.**, 702 Beacon St., Boston 15, Mass.

Circle 662 on Page 19

Plug Valves

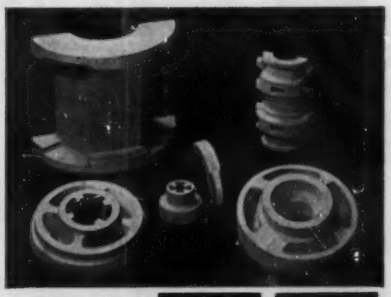
have Teflon sleeves

Tufline instrument plug valves, rated for 300 psi ASA service, are available in sizes ¼ through 1 in. Valves, which have screwed ends and Teflon sleeves, are recommended for on-off use on rated pressures within temperatures of −50 to +400 F, with gas or liquid, corrosive or noncorrosive media. Sculptured interior body bore provides a marked increase in the resilience of the Teflon sleeve, assuring leakproof shutoff even under conditions of fluctuating temperature. In-

"User Reports" prove... BEARIUM METAL out-performs... wears longer than all other types of bearing materials.

BEARIUM METAL'S amazing superiority is due to the uniform dispersion of microscopic lead particles within the copper-tin grains rather than between the grain boundaries as found in ordinary bronzes. Result is that it will not seize or score the shaft nor will it melt out like babbitt—even in applications where a liquid other than oil must be used as the lubricant.

If you have a bearing application calling for dependable, trouble-free performance, by all means BEARIUM METAL *is your best buy in bearing bronze.* Try it on one of your toughest jobs. You'll be glad you did!



Bearium Metal *Ordinary Leaded Bronze*

FEATURES: Non-Seizing and Non-Scoring • Long-Wearing • Self-Lubricating • Low Coefficient of Friction • High Compressive Strength • Resistant to Shock Loads • Sound, Uniform Structure.

AVAILABLE IN: cored and solid bars, centerless ground rods, machined parts, pattern castings.

Write for the BEARIUM METAL *story.*

BEARIUM METALS CORP.
192 Mill St., ROCHESTER 14, N. Y.
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NEVIN ENGINEERING ASSOCIATES
PACIFIC PALISADES, CALIF.
In Canada:
BEARIUM METALS OF CANADA, LTD.
RICHMOND HILL, ONT.

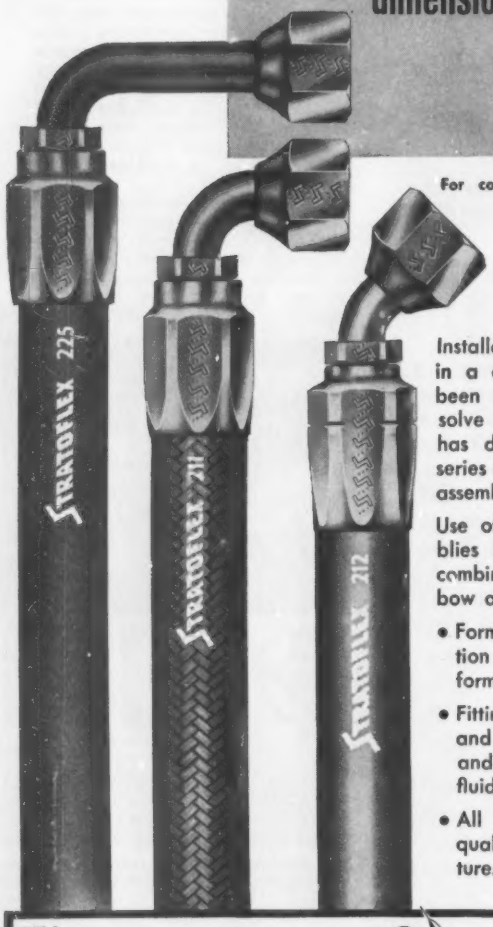
Circle 516 on Page 19

NOW AVAILABLE

STRATOFLEX

FLARED TUBE TYPE ELBOW FITTINGS AND ASSEMBLIES

For confined space installations where hose fittings of minimum dimensions are required



For complete information, write for Bulletin S-4 today.

Installation of hose assemblies in a confined space has long been an industry problem. To solve this problem, Stratoflex has developed a flared tube series of elbow hose fittings and assemblies.

Use of these Stratoflex assemblies eliminates the need for combinations of fittings and elbow adapters.

- Form tubing used for fabrication of fittings to allow uniform flow.
- Fittings available for medium and high pressure applications and for transmission of all fluids.
- All fittings are quality steel, quality controlled in manufacture.

SFS-9

STRATOFLEX Inc.

P.O. Box 10398 • Fort Worth, Texas

Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto
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Atlanta, Chicago
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Detroit, Fort Wayne
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Pittsburgh, San Diego
San Francisco, Seattle
Toronto, Tulsa

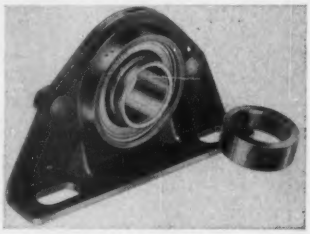
verted tapered plug and bottom diaphragm cover seal are designed so that line pressure reinforces plug seal. No lubrication is required. Other features include troublefree operation, minimum maintenance, quick visual operation, and easy turning. Valves are available in standard 303 and 316 stainless steel. **Continental Mfg. Co.**, 230 Park Ave., New York 17, N. Y.

Circle 663 on Page 19

Pillow-Block Unit

accommodates ½ to 1 7/16-in. shaft sizes

Low-cost PBS pillow-block incorporates high-quality bearings. Pressed-steel housing provides a precision bearing-to-housing fit and true self-aligning bearing. Unit ac-



commodates shaft sizes between ½ and 1-7/16 in. **Fafnir Bearing Co.**, 37 Booth St., New Britain, Conn.

Circle 664 on Page 19

Precision Potentiometers

for critical applications

Developed especially for high-reliability applications, 1 1/16-in. diam potentiometers meet their original specifications after 2000 hr of operation at 150 C. They also operate during 150 g shock and vibration. Standard resistance values range from 100 through 50,000 ohms. All values can be obtained with conformities of 0.14 per cent if required. Terminals are guaranteed against any type of damage except breaking off of turrets, which re-

Circle 517 on Page 19

Webster hydraulics raise production, lower costs

Two ton push-up! Second story operators like this powerful lift truck speed material handling and construction — save time, money. Thanks to hydraulics! Fingertip control raises the load, lowers it — tilts it forward or back. And a Webster Directional Control Valve channels the action. Deftly. Accurately.

Where space is at a premium — this versatile valve fits in. It's the smallest size for rating! Operating pressures range to 2000 psi, shock pressures to 5000 psi . . . with lowest back pressure. Inlet and outlet connections can be made from the same end to simplify hook up. And it's provided with alternate porting positions. Sizes from single spool to 6 spools; capacities from 20 to 40 gpm. Parallel design permits control of up to 6 independent circuits!

Build construction equipment? Machines for industry or agriculture? Keep this Webster Directional Control Valve in mind.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

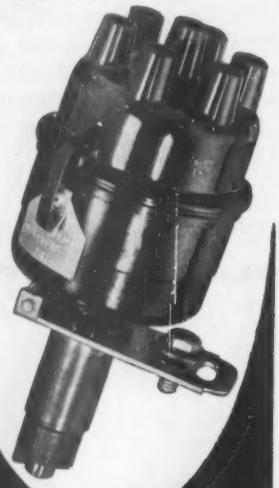
RACINE · WIS

STACK TYPE
DIRECTIONAL CONTROL VALVE
Bulletin HY 1 contains complete engineering data — installation, performance, specifications. Write for it!

example...

FIBERITE

Reinforced phenolics at work...



for ELECTRIC AUTOLITE distributor bowls

Electric Autolite of Toledo needed a plastic molding compound for ignition distributors in automotive and industrial engines. The molded part must maintain rigid dimensional tolerances under very adverse conditions of temperature and humidity. Autolite specified Fiberite No. X-2414 cotton fiber reinforced phenolic. Here is Autolite's report:

1 Dimensionally stable
2 Impact resistant
3 Heat resistant
4 Corrosion resistant
5 Light weight
6 Easily machined

EXPLORE FIBERITE

If you need a reliable molding compound with excellent electrical and mechanical properties plus the best in resistance to shock, chemicals and heat, explore Fiberite.

We have formulations to fit a variety of applications. Our research department is at your disposal. Write for the Fiberite catalog.

SALES OFFICES IN PRINCIPAL CITIES

FIBERITE MOLDING COMPOUNDS

THE FIBERITE CORPORATION
Dept. MD-10
510-520 W. 4th St.
Winona, Minnesota

Circle 519 on Page 19

quires approximately 45 oz-in. torque. Carter Mfg. Corp., 23 Washington St., Hudson, Mass.

Circle 665 on Page 19

Precipitation-Hardening Alloy

has high tensile and yield strengths

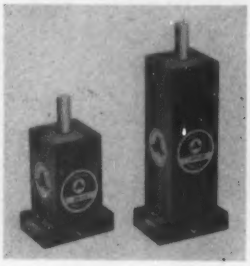
Precipitation-hardening alloy of copper, lead, nickel, and phosphorus is designated Leaded Nickel Copper-831. Properties include high corrosion resistance, high tensile and yield strengths, high electrical conductivity, and free machining quality. Combination of properties suggest uses such as electrical contacts, connectors, control elements for power tubes, and structural elements now using copper. It is produced in round rod in sizes from 3/32 to 1¼ in. diam. American Brass Co., Waterbury, Conn.

Circle 666 on Page 19

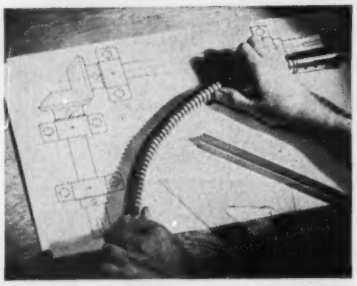
Air Clamps

for horizontal or vertical mounting

Two spring-return air clamps, Models ACM-110 and ACM-120, have sizes of 1⅛ in. bore x 1 in. stroke and 1⅛ in. x 2 in., respectively. Bodies are Zamak alloy, and piston rods are ground and polished stainless steel. Holes are provided both in the body and base for either horizontal or vertical mounting. Clamps feature U-cup



SOLVE POWER TRANSMISSION PROBLEMS WITH STOW FLEXIBLE SHAFTING



THE EARLY STAGE OF DESIGN PLANNING IS THE TIME TO CONSIDER STOW FLEXIBLE SHAFTING.

Flexible Shafting can solve many complex power transmission problems normally encountered in transmitting power through a curved path or between components which have relative motion most efficiently, and more economically.

Use of standard or specifically designed power drive flexible shafting reduces or eliminates alignment and maintenance problems . . . does away with complex and expensive arrangements . . . removes danger of exposed moving parts.

CHECK THESE ADVANTAGES:

• **Simplicity of Design**—greater freedom to locate components . . . ideal for connecting components having relative motion.

• **High Efficiency**—ranging from 80% to 95%.

• **Safety**—replaces exposed universal joints and shafts in hazardous locations.

• **No Alignment Problems**—accuracy of alignment, so important on conventional drives, is not required.

When next you have a specialized power transmission problem . . . check with STOW before designs have advanced too far. STOW engineers are ready to help you.

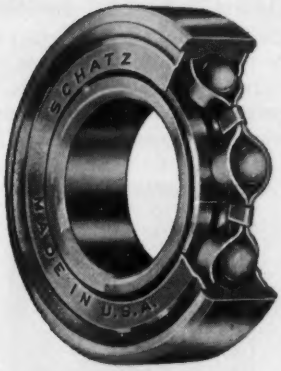
Write for Engineering Bulletin No. 570 and a free torque calculator.

STOW
MANUFACTURING CO.
11 Shear St., Binghamton, N. Y.

Circle 520 on Page 19

Name your load and speed combinations...

Schatz makes the most varied line of Ball Bearings to fit your needs



"Functional Precision" Ball Bearings—BR series

One piece race type with ball cage. Designed to give all the precision you require under certain ratios of load, speed and life expectancy. Available in open type, single or double shielded, single or double sealed with Schatz patented low friction plastic seal. Or with one shield and one seal on special order.

23 sizes from 3/16" to 1"—6 types in each size + specials

"Commercial" Ball Bearings

The most complete and varied line anywhere.

UNGROUND BALL BEARINGS "TYPE A"—Every standard type—radial, thrust and radial thrust.

GROUND BALL BEARINGS "TYPE B"—Used and recommended where greater accuracy and smoother running qualities are needed and where loads are heavier and speeds higher.

1033 sizes to match your Bearing Application Needs

• See our Catalog in SWEET's

FILL IN AND MAIL

We'll fit these bearings—or special types and sizes to your special needs. Just fill in your application problem below—attach to your letterhead and mail.

THE SCHATZ MANUFACTURING COMPANY, Poughkeepsie, N. Y.

Here's our bearing problem. What do you suggest?

APPLICATION_____

LOAD (radial, thrust or both)_____

SIZE_____

SPEED_____

LIFE FACTOR_____

OPERATING CONDITIONS_____

SPECIAL CONDITIONS_____

Name_____ Title_____

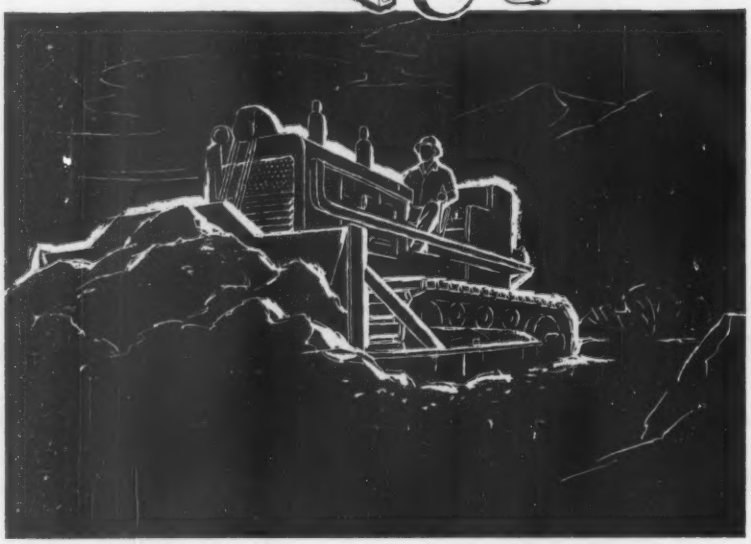
Company_____

Address_____

City_____ Zone_____ State_____

SCHATZ
BALL BEARINGS

from MIDGET CARS . . .



to MIGHTY CRAWLERS

Both are driven by Rockford Spring-Loaded Clutches. These versatile power-links drive many vehicles of all types and sizes. Torque loads range from 50 to 2,530 ft. lbs.! Sizes vary from the compact 6" clutch to the powerful 16" double plate unit. Positive, full-motion driving power with smooth starts and controllability is yours with Rockford Clutches. Write today for illustrated brochure.

SPRING-LOADED ROCKFORD CLUTCH

ROCKFORD CLUTCHES

ROCKFORD CLUTCH DIVISION BORG-WARNER

311 CATHERINE ST. ROCKFORD, ILLINOIS

Export Sales Borg-Warner International 36 So. Wabash, Chicago, Ill.

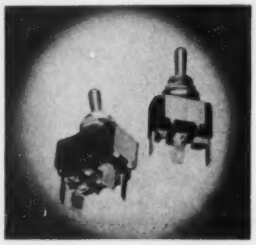
piston packing and oil-type bearing for minimum friction. **Allenair Corp.**, 255 E. 2nd St., Mineola, N. Y.

Circle 667 on Page 19

Toggle Switches

have ¼-in. wide male tab terminals

Single and double-pole, aircraft-type toggle switches have ¼-in. wide male tab connections for use with Burndy, AMP, or Kent female connectors. Switches meet all applicable military specifications. They



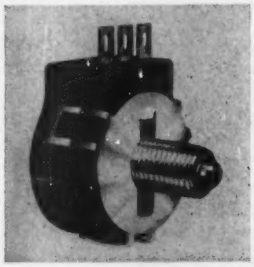
are available in all circuit configurations including momentary on-off modes, and are designed for either dc or ac applications up to 1600 cycles. Tab connections are brass, electrotinned to prevent corrosion. Switches are supplied with counting nuts and sleeve lockwasher. **Kulka Electric Corp.**, 633-643 S. Fulton Ave., Mt. Vernon, N. Y.

Circle 668 on Page 19

Plastic-Case Potentiometer

meets MIL-R-19A and MIL-R-19/1A specs

New ¾-in., plastic-case potentiometer meets MIL-R-19A and MIL-R-19/1A specifications. O-ring shaft seal and complete internal sealing virtually eliminate effects of humidity, salt spray, and similar environmental problems. Unit provides the same protection as en-



Circle 522 on Page 19

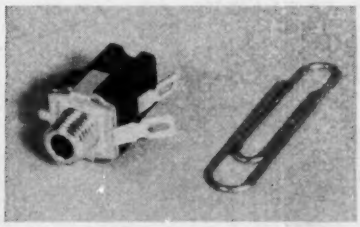
capsulation in less space. Resistance range is 1 to 20,000 ohms, ± 5 per cent. Unit dissipates 1.5 w at 40 C. Torque is 0.3 to 6 oz-in., and weight is 0.02 lb. Potentiometer is available with split or plain bushings, 1/4 or 3/8 in. diam. **Waters Mfg. Inc.**, Wayland, Mass.

Circle 669 on Page 19

Miniature Jack

is furnished in color coded housing

Improved miniature jack is available in open, closed, and transfer circuit configurations. Type J5 jack is fully enclosed in color-coded



thermoplastic housing. Design eliminates pile-up construction and hand adjusting. **Carter Parts Co.**, Dept. 21, 3401 Madison St., Skokie, Ill.

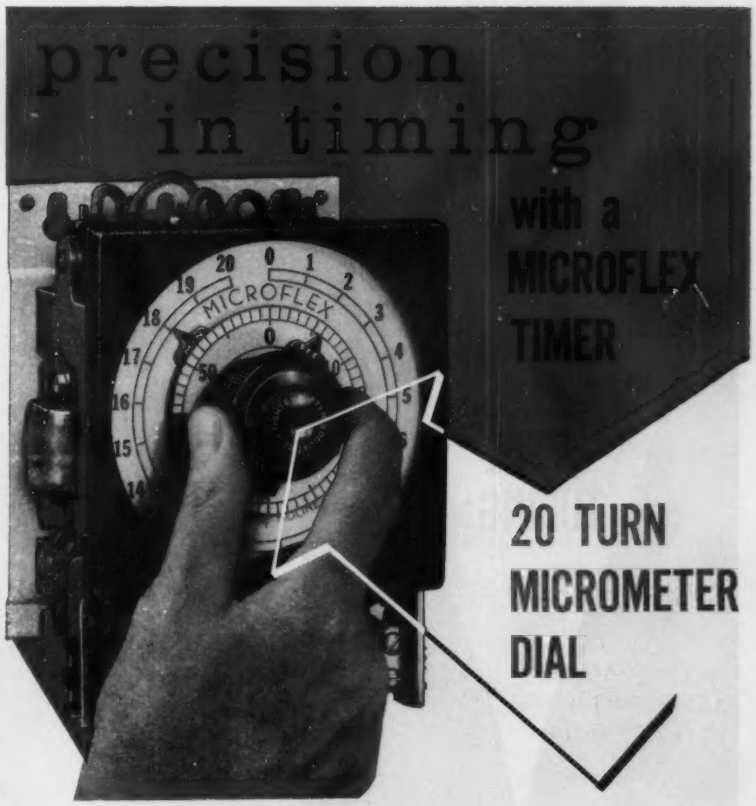
Circle 670 on Page 19

Hermetic-Seal Bushings

are soldered in metal equipment enclosures

Model M-1003 hermetic-seal, feed-through bushings are constructed of solid cast-epoxy resin. Having no internal voids to be filled with oil, they can be mounted in any position. Units are designed for solder-installation into hermetically sealed metal equipment enclosures. Special internal stress-control structure gives uniform field distribution over the epoxy surface. Unit is capable of corona-free operation at 40 kv and has a peak-pulse operating level of greater than 70 kv for air-to-oil or 140 kv oil-to-oil operation. Epoxy construction also contributes a thermal-shock resistance range from −60 to +175 F, small over-all length of 5 in., and low weight of 16 oz. **Components For Research Inc.**, 979 Commercial St., Palo Alto, Calif.

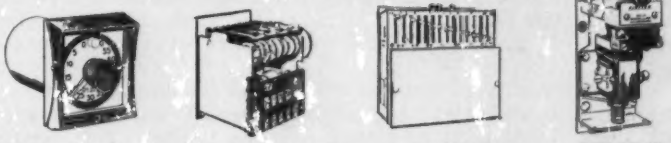
Circle 671 on Page 19



The EAGLE Microflex Timer provides unequaled accuracy in closing or opening a circuit. An easy-to-read 20 turn double micrometer dial speeds the selection of new settings over full 7200° range and permits a one-glance check of previously set intervals.

- PIN-POINT ACCURACY is possible with 1200 conveniently spaced dial markings. No guessing at in-between points. Accuracy maintained by patented pinion and threaded axle.
- 9 DIFFERENT ACTIONS are available for each of 3 SPST 15 ampere contacts which can be selected according to circuit requirements.
- PLUG-IN COMPONENTS allow rapid replacement of timers. Large capacity contacts eliminate additional load relays.

OTHER POPULAR HIGH QUALITY EAGLE TIME-COUNT CONTROLS



CYCLE-FLEX PLUG-IN TIMER | CAM TIMERS | MULTI-CIRCUIT TIMERS | TIME DELAY RELAYS

For more details on the Microflex Timer, write for free bulletin 110, or contact your local Eagle Representative listed in Thomas Register or Phone Directories in 25 principal cities.

BLISS

EAGLE SIGNAL COMPANY • Moline, Illinois

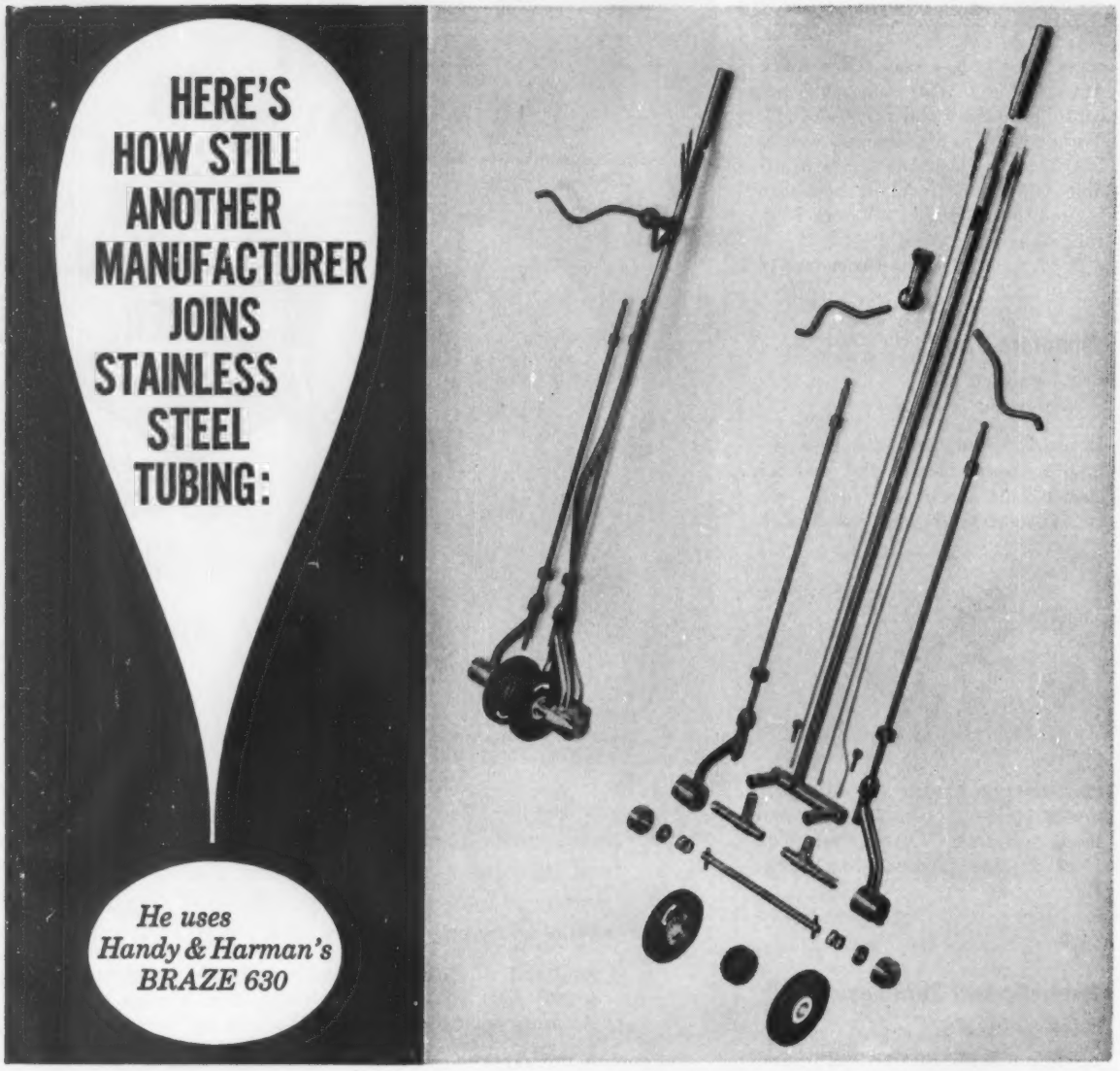
A DIVISION OF THE GAMEWELL COMPANY, AN E. W. BLISS COMPANY SUBSIDIARY

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS

Circle 525 on Page 19

HERE'S HOW STILL ANOTHER MANUFACTURER JOINS STAINLESS STEEL TUBING:

He uses Handy & Harman's BRAZE 630



He's one of many manufacturers and fabricators who have found—to their lasting satisfaction—that Handy & Harman silver alloy brazing is the final answer to stainless steel joining problems.

Super-Donic Manufacturing Company, Atlanta, Georgia, manufactures "Dual Arm Transmissions" for the dental industry. Most everybody has—at one time or another—seen and/or felt this unit in operation.

It is fabricated of small diameter 304 and 316 stainless steel tubing and, in its assembled form, consists of some 17 separate brazed joints. Joints must be strong, corrosion resistant and neat-appearing.

Each of the 17 joints is hand-torch brazed with Handy & Harman BRAZE 630 wire and HANDY FLUX TYPE B-1. There's no question that this is a unique application. There's no question, either, that the application is stainless steel. The ease and economy with which this manufacturer solves his problems can be just as readily applied to *your* stainless steel joining problems.

Strength, production speed, electrical and thermal conductivity, gas and liquid tightness and low cost are *natural* benefits of silver alloy brazing. We think it worth your while to learn more about this remarkable metal-joining method—we'll be glad to send you any information you ask for. Handy & Harman, 82 Fulton St., New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

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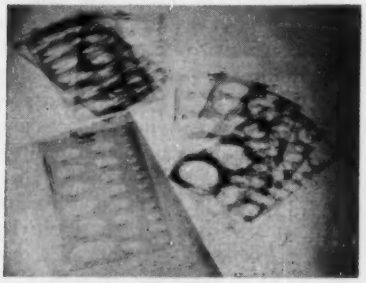
ENGINEERING DEPARTMENT

EQUIPMENT

Ellipse Template Set

consists of ten templates with 246 cutouts

Set of drafting templates consists of ten templates with 246 cutouts from 15 through 60 deg in increments of 5 deg, and from 3/8 through 2½-in. major axes. Each template has an extended tab showing the degree of the cutouts; each cutout on each template has centering or locating pinholes for both major and minor axes. Templates are 6 x 10 in., made of tinted, instrument-



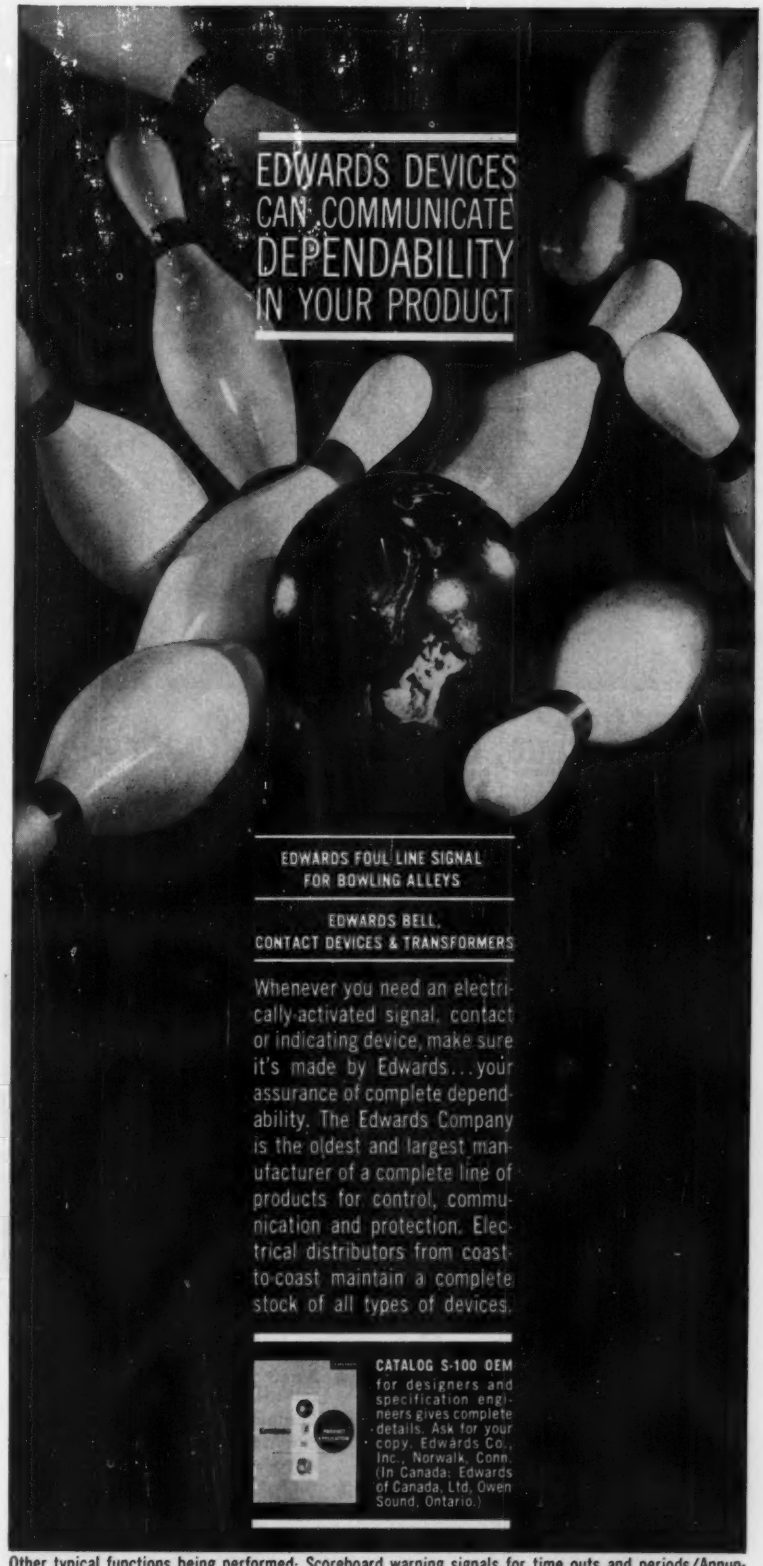
grade plastic. Material is 0.020-in. gage for shadowless viewing and high tracing accuracy. Templates are supplied in a protective polyethylene envelope. **Timely Products Co.**, Baltimore, Ohio.

Circle 672 on Page 19

X-Y Recorder

is compact lightweight unit

Model 135 X-Y recorder has transistorized circuitry and is only slightly larger than the size of the recording paper itself. Dimensions are 10½ x 16⅛ x 4½ in., and unit weighs 20 lb. Instrument features built-in calibrated X-axis time sweeps, plus 16 calibrated ranges on each axis, with an infinitely variable vernier. It can be rack mounted or used on a bench in horizontal, inclined, or vertical plane. Detachable carrying handle makes the lightweight unit easily portable. Other features in-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CATALOG S-100 OEM for designers and specification engineers gives complete details. Ask for your copy. Edwards Co., Inc., Norwalk, Conn. (In Canada: Edwards of Canada, Ltd, Owen Sound, Ontario.)

Other typical functions being performed: Scoreboard warning signals for time outs and periods/Annunciator indicators for motor trouble on conveyors and escalators/Oil pressure warning on diesel engine/Fire warning signals for aircraft/Rear door signals for busses and trucks/Machine gun sound for toy airplane rides/Activating devices for automatic electric scoreboards/Activating device for electric sprayers/Stewardess call signals on aircraft and trains/Telephone buzzers/Activating push buttons and signals for pari-mutuel recorders/Dictating machine signal/Trouble signals on (visual or audible) control panels/Back-up signals on taxis, trucks and busses/Aircraft landing gear warning signals

Circle 527 on Page 19

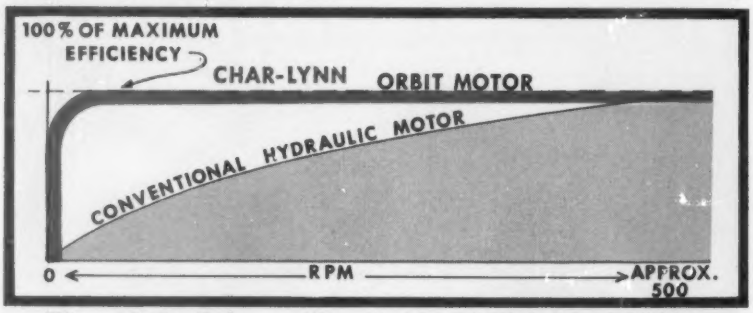
You've never seen a motor like this!

PAT. NO. 2,821,171

A High Torque, Low Speed Hydraulic Motor

It's Here—A NEW concept in fluid power mechanics has brought about the development of a totally new fluid motor—A *High Torque—Low Speed* motor.

These motors open up complete new areas for design, never before possible. They offer a practical and economical hydraulic solution to the age-old problem of providing High Torque at Low Speeds for constant and variable speed drives—hydrostatic transmissions and remote controls *without* bulky, costly mechanical drives and gear reducers.



Whereas hydraulic losses make some conventional designs prohibitive at the lower speeds, Char-Lynn ORBIT MOTORS maintain high efficiency over the complete operational range.

- Speeds from 0—800 RPM
- Torques to 3300 inch lbs.
- Starting torque substantially equal to running torque
- Fully reversible — instantaneous starting—stopping
- Only 3 moving parts
- 4 types of mountings available
- 3 port sizes—7 power element selections
- Compact—lightweight
- Eliminates costly and complicated power transmissions
- High volumetric and overall efficiency

Write for complete 8 page brochure on ORBIT MOTORS

Char-Lynn

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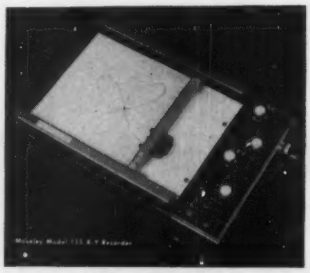
PA 1-5761 MD-10



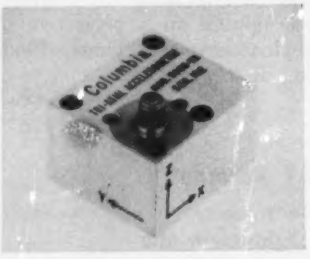
clude high input resistance, self-contained vacuum paper hold-down, full-range calibrated zero set and zero suppression on each axis, plus high recording speed. **F. L. Moseley Co.**, 409 N. Fair Oaks Ave., Pasadena, Calif.

Circle 673 on Page 19

Triaxial Accelerometer

miniature unit weighs only 37 grams

Model 510-TX miniature triaxial accelerometer performs simultaneous measurements of acceleration in three mutually perpendicular planes due to shock and vibration. Suitable for applications where space and weight requirements are limited, unit is aluminum-block steel, measures 1⅛ x 1 x ⅝ in. and weighs 37 grams. It has a high sensitivity and a frequency response of 2 cps to 5 kc. Resonant frequency is 100 kc, maximum acceleration 1000 g, and amplitude linearity, ± 1



per cent. Temperature range is −65 to +300 F for standard units and −65 to +500 F for high-temperature units. **Columbia Research Laboratories**, McDade Blvd. & Bullens Lane, Woodlyne, Pa.

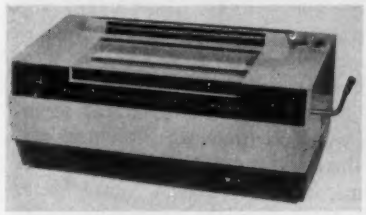
Circle 674 on Page 19

Portable Photocopier

has 12-in. capacity

Contouramatic Mark III is a lightweight (22 lb), compact, portable

photocopier. It makes exact, permanent, black-and-white copies of any mark on paper, including ballpoint pen, colored inks or crayons, spirit duplication, and rubber stamped copy. Up to 12-in. wide originals of any length can be copied on regular bond-type paper, featherweight paper, card stock, and various films for reproduction masters. Disposable sealed-plastic container eliminates all chemical handling and prolongs solution life. Unit has all controls, copying operations, and paper storage in front for easy access. Single-action control, a lever located at the side of the machine, activates the mechanism and causes solution to flow into proc-



essing chamber. Automatic pressure-flow design keeps solution fresh, free from evaporation until machine is turned on. **F. G. Ludwig Inc.**, Old Saybrook, Conn.

Circle 675 on Page 19

Digital Tape Transport

operates with selectable or variable speeds

Model DT 10 low-speed digital tape transport reads, writes, or reads after-write from 0.1 to 15 ips in specifically selectable speeds or continuously variable speeds controlled manually or remotely for any type computer format. Continuously variable speed permits maintenance of constant level buffering; control from an external, fixed, or variable strobe for synchronization of character output rate; or contant character output rate by synchronization of tape speed with the recorded format. Tape speed settings are held to within $\pm 1/4$ per cent independent of line voltage and frequency. Constant tape tension is insured by separate reel servos. Unit is designed for mounting in standard 19-in. racks or in special side-mounting drawer frames. It is constructed on a completely modular principle, per-

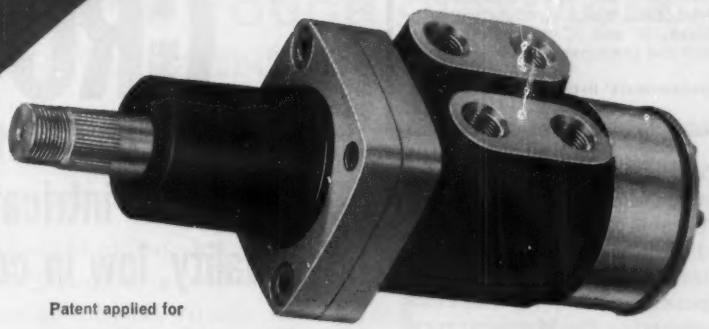
NEW FLUID STEERING

REPLACES ENTIRE MECHANICAL STEERING SYSTEM

ORBITROL is a completely integrated steering control system that eliminates any mechanical linkage to the axle. The all NEW ORBITROL provides remote rotary servo control with sensory direction and delivery measurement within the same unit... the ideal concept in self-propelled vehicles.

Char-Lynn®
ORBITROL

ORBITROL can be used with any remote actuator, such as a linear cylinder, rotary cylinder, or hydraulic motor. With power off, ORBITROL becomes a pump to furnish means for emergency steering.



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- Highly responsive

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Char-Lynn

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Pressure: to 540 psi.

Ten orifice sizes: 1/64" through 1/4".

Wide voltage range: standard with 115V. AC.; also 12, 24, 208, 230, 460V. AC. 50/60 cycle.

Body: brass bar stock or 18-8 stainless steel. All moving parts, stainless. Seat disc, synthetic rubber. Sizes, 1/8" and 1/4" NPT. Both conduit and grommet types.

Underwriters' listed as a safety valve

Yes, "Master-mite" is the mighty mite of solenoid valves. Useable on a wide range of media including hydrogen, acetylene, etc. Works right in any position. Small, but with extra strength in the Marsh manner. Coils never overheat. Leak tight. Remarkably quiet.

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GAUGES • THERMOMETERS
VALVES

Circle 530 on Page 19

mitting ease of servicing and highest reliability. **Shepherd Industries Inc.**, 103 Park Ave., Nutley 10, N. J.

Circle 676 on Page 19

Tracing Vellum

has high strengths and good reproduction quality

Draftrace is a 16-lb tracing vellum with attractive visual appeal, high strength, permanence, and reproduction quality. It can be used as a durable tracing paper for engineering, tracing, architectural drawings, map reproductions, and for type-on-masters for whiteprint, letterpress, or offset reproduction.

Draftrace is 100 per cent rag paper, impregnated with a nonyellowing, nonmigrating polymeric resin for lasting transparency. Paper formation is closed, dense, and uniform, and slightly textured surface in the base paper provides good pencil "take." Surface also accepts drawing ink without skipping, feathering, or spreading. It withstands multiple erasures, retaining a good drafting surface. Vellum has high tear strength. It is supplied both in cut-sheet packages of 500 sheets and in 50-yd rolls. **Ozalid Div., General Aniline & Film Corp.**, 60 Corliss Lane, Johnson City, N. Y.

Circle 677 on Page 19

Graphic Recorder

measures down to 1/100 mv

Model JY 120 graphic recorder provides a span of 1 mv full scale, recording voltages as small as 1/100 mv. Unit has a maximum signal-source resistance of 50,000 ohms. Standard features include a pen speed of 1/2 sec full scale, accuracy of 1/2 per cent of span limit of error, and step selection of ranges to 10 v by means of an attenuator on the front panel. Chart width is 5 in., and chart speeds are changeable, with two-speed motors supplied optionally. Instrument is designed with a null-balance, servo-type, potentiometric, chopper-stabilized system. **Nesco Instruments Inc.**, 638 W. 17th St., Costa Mesa, Calif.

Circle 678 on Page 19

GRC tiny die castings

made in one fast automatic operation ...simple or intricate parts, high in quality, low in cost

Gries' exclusive patented methods make possible wide design latitude . . . assure uniformity, accuracy and smooth surfaces on small parts of all types . . . for a wide variety of uses . . . at substantial savings. GRC die castings leave the machines already trimmed. In addition GRC's unique single cavity die casting techniques offer new short-cuts in assembly . . . new approaches in product design through our exclusive methods.

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Maximum Sizes up to 1¾", ½ oz.

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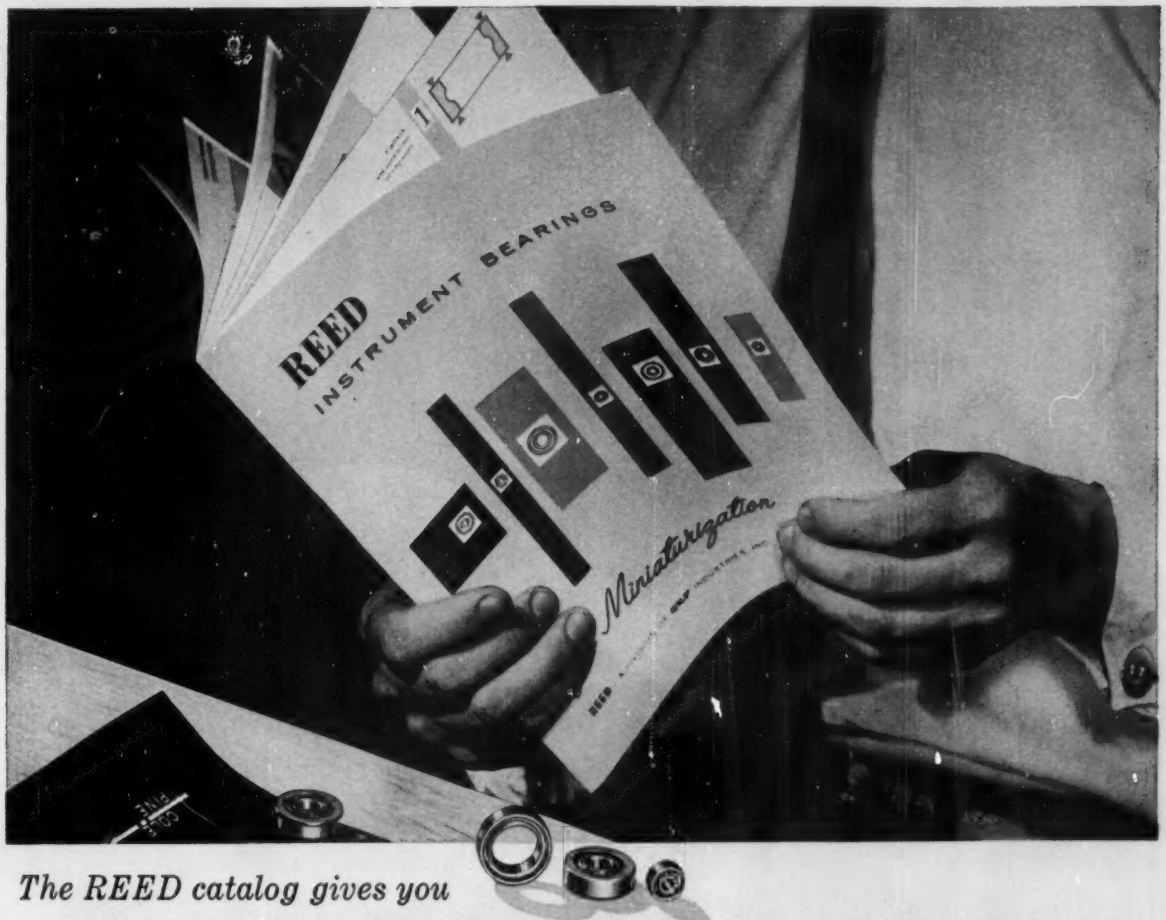
Circle 531 on Page 19



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REED INSTRUMENT BEARING COMPANY
LOS ANGELES, CALIFORNIA

Division of
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Circle 532 on Page 19

ON THE HIGH COST OF VIBRATION IN AIR MOVING EQUIPMENT

Have you considered the fact that normal excitation in your product can produce resonance and structural failure in the air moving components? **We** have, and this fact is "pocketbook and problem insurance" for our customers. For instance: We know that motor rotational frequencies... blade frequencies... magnetic frequencies... are basic sources of excitation present in every fan or blower application. When the above coincides with the natural response of the unit, this means resonance and—plenty of trouble. At Torrington, each product of ours is designed, engineered and tested for an optimum range of performance, with harmful or costly resonances "designed out." It pays to know these performance characteristics—and to take advantage of this kind of knowledge. Check your air moving problems or your products with Torrington.

THE TORRINGTON MANUFACTURING COMPANY

AIR MOVING DIVISIONS Torrington, Connecticut; Van Nuys, California; Rochester, Indiana; Oakville, Ontario

THE ENGINEER'S

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How to Communicate Policies and Instructions. *By Joseph D. Cooper; 352 pages, 10 by 11½ in., loose-leaf binder; published by Bureau of National Affairs Inc., 1231 24th St. N.W., Washington 7, D. C.; available from* MACHINE DESIGN, *$14.75 per copy postpaid.*

This book contains practical information for those who prepare—or determine policy for preparing—written instructions for someone else. Operations manuals such as policy manuals, technical manuals, training manuals, and consumer manuals are covered.

A section is devoted to planning an organization-wide instruction system. It includes such practical problems as who is responsible, qualifications of writing staff, selling the program to top management, and obtaining co-operation from those below who must use the instructions to best advantage.

The Robertson Guide to World Screw Thread Standards. *41 pages, 6 by 9 in., paperbound; published by W. H. A. Robertson & Co. Ltd., Lynton Works, Bedford, England; $1.50 per copy.*

More than 2000 screw-thread standards covering the 33 countries which have national standards for screw threads are listed. Illustrations for 108 external screw-thread forms are included.

Mechanics. *By Keith R. Symon, professor of physics, University of Wisconsin; 557 pages, 6¼ by 9¼ in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from* MACHINE DESIGN, *$10.50 per copy postpaid.*

Development of mechanics theory proceeds directly from Newton's laws of motion. More advanced methods using Lagrange's equations and tensor algebra are then introduced. Only a knowledge of differential and integral calculus is presupposed.

This second edition contains three new chapters and several additional

←Circle 533 on Page 19

SMITH

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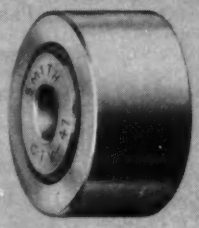
CTA CAM FOLLOWER



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Circle 534 on Page 19

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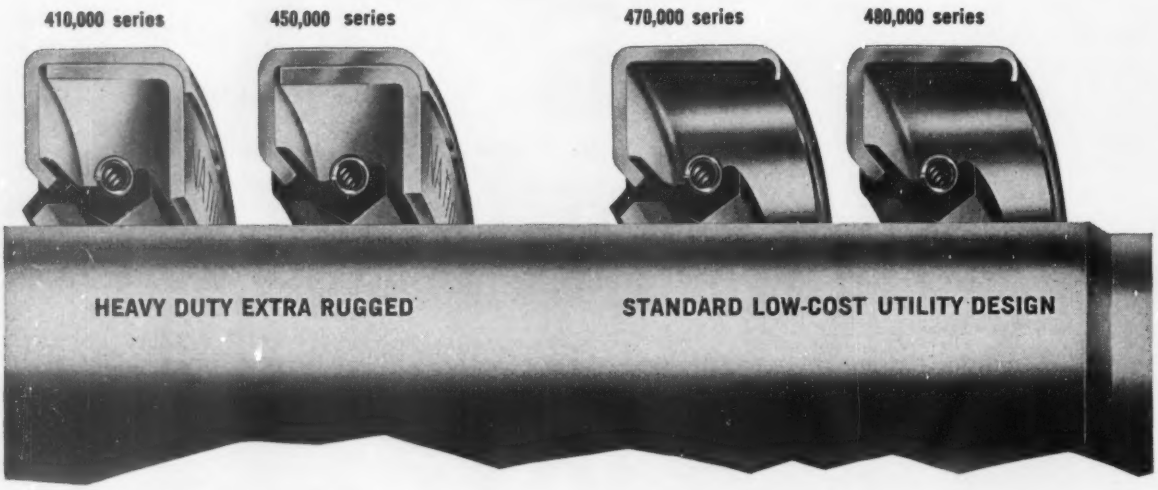

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Circle 535 on Page 19

sections to earlier chapters. Lagrange's equations include section on Lagrangian treatment of the vibrating string, Hamilton's equations. and Liouville's theorem. Algebra of tensors, the inertia tensor, and the stress tensor are developed and discussed in the new chapters.

Small Gas Turbines and Free Piston Engines. *By Arthur W. Judge; 328 pages, 5½ by 8¾ in., clothbound; published by and available from Chapman & Hall Ltd., 37 Essex St., London, England; $6.60 per copy.*

Theoretical and experimental information about small gas turbines is presented. Practical considerations and typical successful commercial engines—including small free-piston engines—are discussed.

Gas turbines ranging from the smallest models of 30 to 40 bhp, up to about 1000 to 1500 bhp, are covered. Emphasis is on the medium-output engines.

Government Publications

NASA Technical Notes. Copies of publications listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TN D-420. An Evaluation of Some Current Practices for Short-Time Elevated-Temperature Properties Tests of Metals. By Charles R. Manning Jr. and George J. Heimerl, Langley Research Center; 44 pages, 7¾ by 10¼ in., paperbound, side-stapled; $1.25 per copy.

Constant strain-rate, constant head-speed, and dual strain-rate tests were conducted on 2024-T3 aluminum alloy, HM21A-T8 and HK 31A-H24 magnesium alloy, and 12MoV stainless-steel sheet. Need for uniform testing practices is shown.

TN D-424. Investigation of the Buckling Strength of Corrugated Webs in Shear. 29 pages, 7¾ by 10¼ in., paperbound, side-stapled; $0.75 per copy.

Design charts for determining buckling strength of corrugated shear webs were developed. Charts are applicable to webs with supported edges. Edge rotations of the web along lines of support may range from unrestrained to completely restrained edges.

Results of shear tests on seven beams with corrugated webs are presented and analyzed.

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161457. Explosive Forging. By V. Philipchuk, American Potash & Chemical Corp.; 55 pages, 8½ by 11 in., paperbound, side-stapled; $1.75 per copy.

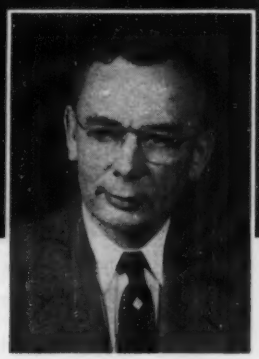
Explosive forgings made from aluminum alloys were investigated. Physical and metallurgical characteristics of the explosive forgings proved to be comparable to those of conventional aluminum forgings.

PB 161500. Fatigue Behavior of 2014-T6, 7075-T6 and 7079-T6 Aluminum Alloy Regular Hand Forgings. By D. A. Paul and D. Y. Wang; 26 pages, 8½ by 10¾ in., paperbound, stapled; $1.00 per copy.

Effects of forging direction on fatigue strength of aluminum alloys were investigated with the alloys in the unnotched and notched conditions. Test results are discussed.

Circle 536 on Page 19→

profiles in plastics



by **B. FRANK HANTZ,** *Vice President*
AMERICAN INSULATOR CORPORATION
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"Aico's enviable position in the field of molded plastics has been attained largely through customer satisfaction and service. Since 1916, Aico has been a major supplier of molded plastics to many of America's pace-setting industries. Each molding job presented its own unique problems . . . problems which were successfully solved by the integrated facilities and coordinated skill of expert craftsmen within the Aico organization. Perhaps the best proof of Aico's efficient service . . . and satisfaction delivered . . . is the record of new assignments we receive from customers we've served in the past."

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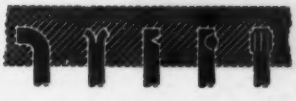

INSERTS . . . may be used in plastic parts as fasteners, to support loads, simplify handling or facilitate assembly. (They may serve functional purposes or may be used purely for decoration.) Smooth rod inserts (see sample above) may be securely anchored by bending, splitting, notching, swaging or knurling. Other types of inserts are fully covered in Aico's booklet "Good Plastics Design Makes Cents." Coupon will bring your FREE copy.

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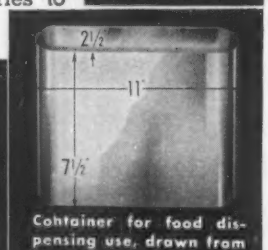
Releaser-tank for pipeline milker, drawn and heliarc welded from 18 gauge, type 302 stainless steel.

Ingredient Container for Coffee Dispensing Machine, drawn from 20 gauge 302 — 18.8 stainless steel.

The shapes illustrated here give some indication of Polar Ware's capacity for unusual performance — an ability that turns many problem runs into routine jobs. But what can't be shown — because of its confidential nature — are the cost figures that help make this fifty-year-old company so strong a resource for so many large and small firms everywhere.

If you are working on new designs, or have run into troublesome technical problems on what you are already doing, there's a very good chance that Polar engineers and Polar facilities can give you positive help — in stainless steel, carbon steel or aluminum. Please address your inquiries to the Contract Department.



Container for food dispensing use, drawn from 20 gauge, stainless steel.

Stock pot drawn from 10 gauge aluminum.

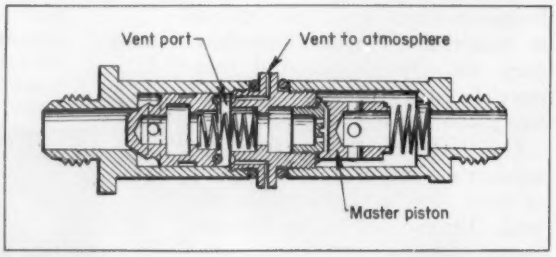
Polar Ware Co.
4500 Lake Shore Road — Sheboygan, Wisconsin

NOTEWORTHY

Patents

Vented Safety Check Valve

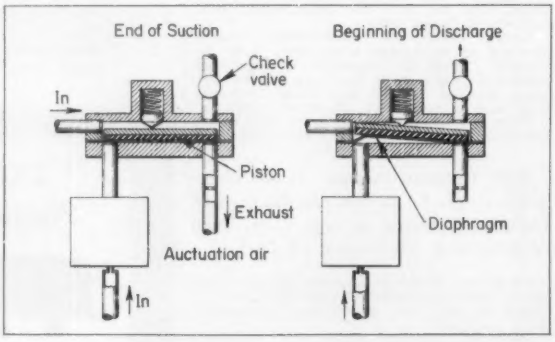
Malfunctioning of a safety check valve assembly is both detected and vented by a dual valve arrangement. In normal flow, passage of the fluid through the first valve displaces a piston which closes the vent ports to permit flow through the second or master valve. When



flow stops, the first valve is seated by a spring. If it fails to seat properly, the vents allow leakage to atmosphere. If the first valve closes properly and the master valve does not, then back-pressure leakage vents to atmosphere. *Patent* 2,953,153 *assigned to the United States of America by Leslie C. Gaul.*

Air-Operated Floating-Piston Pump

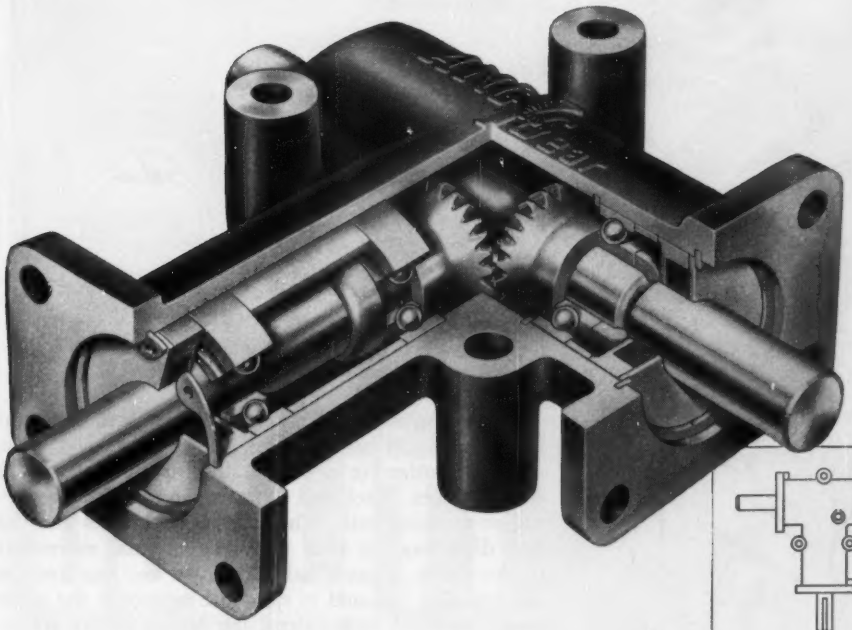
Oil pump is driven by compressed air. The piston and its chamber are rectangular in shape. A diaphragm within the chamber separates the fluid being pumped from the actuating fluid. Rocking motion of the piston and diaphragm uncovers the inlet port to draw oil into the chamber and then covers the inlet port to



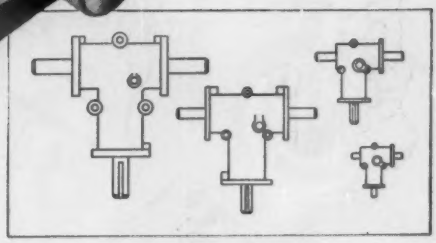
permit discharge of the entrapped oil through a check valve. The diaphragm also serves as the valve for controlling the flow of gas into and out of the air side of the chamber.

A spring-loaded fulcrum accommodates the linear position and rocking motion of the piston. The spring also opposes the force exerted by the actuating fluid

There is only one ANGLgear®... and it is made only by Airborne



Quality of ANGLgear construction is evident in cutaway view. ANGLgear gives you all the features of other drives, plus greater hp range (⅓ to 5); permanent lubrication; and Coniflex* design gears for more even load distribution, reduced wear, quieter operation.



ANGLgear is available from local distributor stocks in 4 sizes, 16 models, with various gearing and shaft options.

ANGLgear – introduced in 1951– is the *original* standardized right-angle drive. It is also the No. 1 product in its field – in sales, availability, quality, performance. Witness the thousands of satisfied customers who have bought ANGLgear to date – for applications ranging from simple manual control of valves to classified installations aboard nuclear submarines.

In design and construction, ANGLgear has been refined to the point of being virtually foolproof, provided it is not grossly overloaded. Take a unit off the shelf, install it, run it–for years. And attention is seldom required.

Besides being maintenance-free, ANGLgear is also easy to design into your power transmission systems because of its universal mounting feature. And it invariably costs less than other types of drives. ANGLgear is distributed nationally and is available immediately from local distributor stocks in the models listed here. Special sizes, special gear ratios, etc., can also be furnished. For complete engineering data, contact our local distributor, or write direct for new Catalog IA-58. *ANGLgear design template kits are available on request.*

*Trademark of the Gleason Works

BASIC MODEL DATA

Model	Type	Gear Ratio	HP	RPM Output Shaft	Ultimate Static Torque lb. in. Output Shaft	Shaft Dia.	Wt., lb.
R-300	2-way	1:1	1/3	1800	250	3/8	.5
R-300-2	2-way	2:1	1/5	1800	250	3/8	.5
R-310	3-way	1:1	1/3	1800	250	3/8	.5
R-310-2	3-way	2:1	1/5	1800	250	3/8	.5
R-320	2-way	1:1	1	1800	1000	5/8	2.2
R-320-2	2-way	2:1	3/5	1800	1000	5/8	2.2
R-330	3-way	1:1	1	1800	1000	5/8	2.4
R-330-2	3-way	2:1	3/5	1800	1000	5/8	2.4
R-333	2-way	1:1	2-1/4	1200	1500	3/4	8.7
R-333-2	2-way	2:1	2-1/4	1200	1500	3/4	8.7
R-335	3-way	1:1	2-1/4	1200	1500	3/4	9.0
R-335-2	3-way	2:1	2-1/4	1200	1500	3/4	9.0
R-340	2-way	1:1	5	1200	2500	1	14.5
R-340-2	2-way	2:1	5	1200	2500	1	14.5
R-350	3-way	1:1	5	1200	2500	1	15
R-350-2	3-way	2:1	5	1200	2500	1	15

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Circle 538 on Page 19

ON THIS PICNIC COOLER

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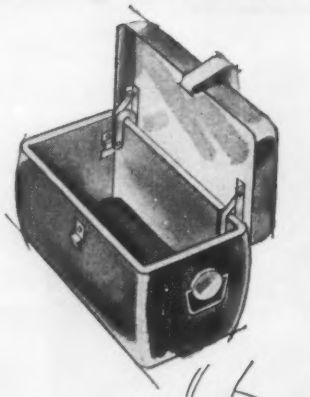
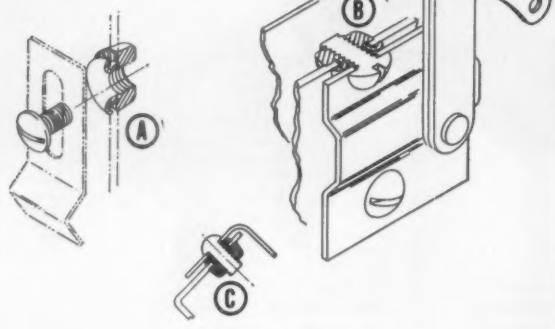
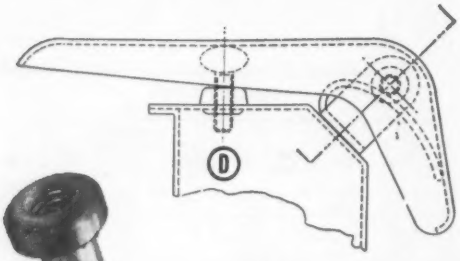






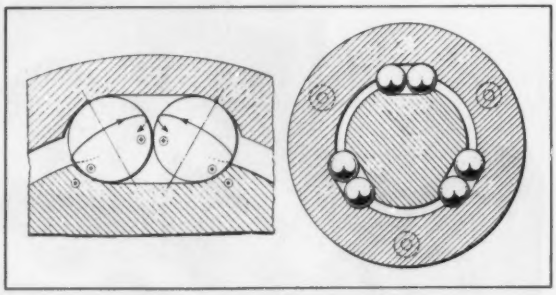
These new internally-threaded tubular rivets cut costs, bring new design freedom in countless applications. On this picnic cooler manufactured by Progress Refrigerator, there are actually six of them. One (A) is a nut plate and spacer for the front catch. Two more (B) are fastening fixtures for each hinge arm base. Another pair (C) serve as nut plates and pivot bearings for the spring-loaded latch. The sixth (D) receives the latch adjusting screw.

With these unique TRS fasteners, you keep all the advantages of threaded attachments, gain the simplicity, speed, economy of rivets ... because they are automatically fed and set on standard high-speed machines, just like tubular rivets. Get the full story from your TRS man soon. Find him in the "Yellow Pages", or write us direct for fast, efficient help with your fastening and attachment problems.

TRS® TUBULAR RIVET & STUD COMPANY
QUINCY 70, MASSACHUSETTS

upon the piston. When the actuating pressure is released, the spring returns the piston to suction position in the chamber. *Patent 2,952,217 assigned to Fairchild Engine and Airplane Corp., Hagerstown, Md., by Torsten H. Lindbom.*

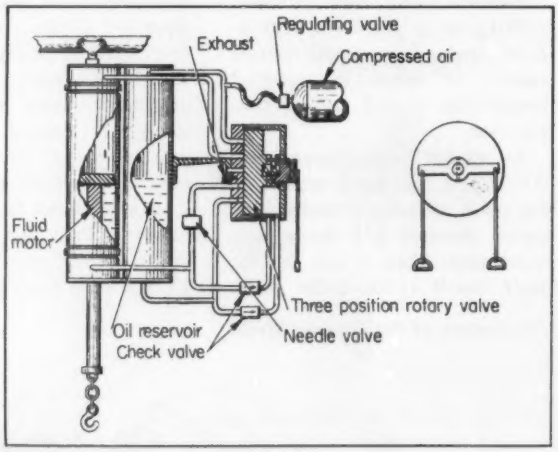
Ball Splines



Friction between splined shafts during relative axial displacements is minimized by using twin rows of balls as load-transferring elements. The spline surfaces are the ball races. Each ball contacts two races and a mating or opposing ball. The shapes of the races and the ball diameters are such that relative axial movement of the shafts causes a ball to roll on one race and on the opposing ball and to spin with respect to the other race. Rows of balls extend the length of the spline. Ball pairs are kept in circumferential alignment by adjacent pairs and by plates at the ends. *Patent 2,952,-145 assigned to International Business Machines Corp., New York, by Herbert E. Thompson.*

Hydro-Pneumatic Hoist Control

Positive positioning of a hoist is attained by a three-position rotary valve in an oil-air control system. The system and the rotary valve are so designed that the pressures tending to seat the valve exceed those tending to unseat it at every position. For example, in the at-rest position of the diagram, unit pressures on the effective areas of opposite faces produce a positive seating force. A check valve prevents the release of en-



ASSURES PREDICTABLE PERFORMANCE OF BARDEN PRECISION BALL BEARINGS

One of the key factors behind the world renowned reliability of *Barden Precision* bearings is quality control. First step in Barden's advanced quality control procedure is inspection of bearing steel to assure its conformance to rigid specifications.

From here on, bearing parts are carefully checked — microscopically, mechanically and electronically — at *every* manufacturing operation. At the end of the line, functional testing of assembled bearing assures that, small quantity or large, every *Barden Precision* bearing will meet your performance requirements.

Typical of Barden quality control instrumentation is the Waviness Gage, a production tester used to check the accuracy of raceway grinding — one of Barden's many contributions to the advancement of the precision bearing art.

Barden quality control — together with Barden methods in manufacturing, bearing assembly, final inspection, lubrication, functional testing and sealed packaging — is your assurance that with *Barden Precision* bearings you get consistent quality from the beginning to the end of each production run.

Barden is a major supplier of standard bearings in sizes from .0469" bore to over 3" O.D., all manufactured to *Barden Precision* standards of dimensional accuracy, uniformity and reliability.

for reliability...specify

BARDEN PRECISION BALL BEARINGS

THE BARDEN CORPORATION. 208 Park Avenue, Danbury, Connecticut

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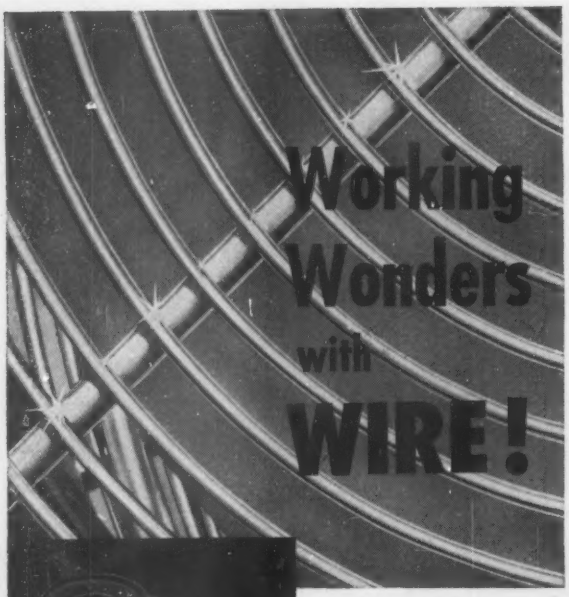
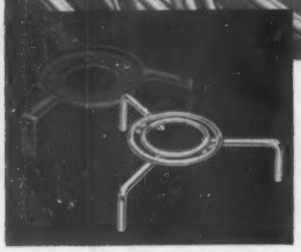
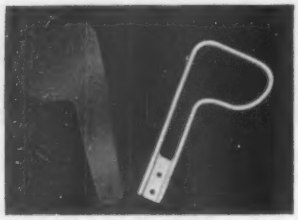
Circle 540 on Page 19

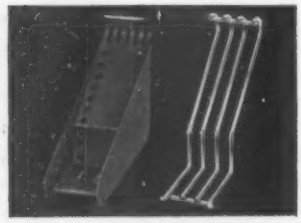




Wire motor mount cut costs, absorbed vibration, reduced weight.



Wire/strip paddle arm for cleaning unit reduced costs 70%; ended noise problem.



Wire guide is lighter, easier to clean, much lower in cost.

Wire and wire/strip components improve the quality, efficiency and appearance of finished products.

CUT COSTS
Wire and wire/strip components save on tooling, machining, and materials.

Improve Design
Wire and wire/strip are strong and light; welds are stronger than parts joined.

Modern Look
Wire and wire/strip offer functional, decorative values. Finishes include Lustre-Zinc® (also available in attractive colors), nickel, chrome, brass, cadmium and electropolished stainless steel.

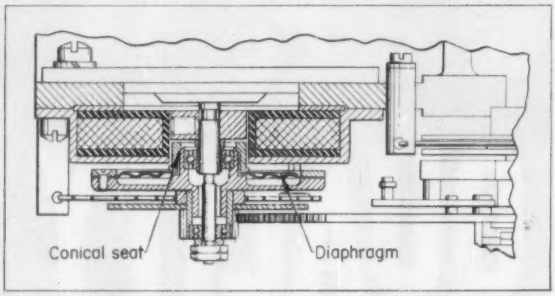
Free Package
Send now for our Wire/Strip component design package. New handbook describes complete production facilities for fabricating wire forms, welded wire and strip assemblies, light stampings and staples.

E. H. Titchener
AND COMPANY
65 CLINTON STREET, BINGHAMTON, NEW YORK

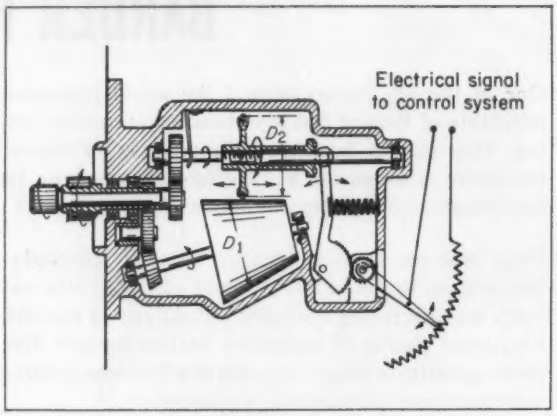
trapped oil on one face and a consequent drop in seating force when the unit pressures tending to unseat the valve have diminished. Check valves assist the rotary valve in locking the fluid motor in any position. A needle valve provides an adjustment for rate of movement of the hoist. *Patent 2,949,894 assigned to Westinghouse Air Brake Co., Wilmerding, Pa. by Ellis E. Hewitt.*

Vibration-Resistant Clutch Assembly

In the disengaged position, electromagnetically operated clutch utilizes a conical seat to center and support a floating friction disc of the engaging pair. The floating disc is attached to the driven shaft by a flexible spring diaphragm. The diaphragm transmits the driving torque when the clutch is engaged. It returns the disc to the conical seat upon de-clutching. This support arrangement prevents fatigue failure of the diaphragm when the assembly is subjected to extreme vibration. *Patent 2,953,227 assigned to the Bendix Corp. by Samuel Gilbert.*



Speed Ratio Measurement



Responsive to the speeds of two independent shafts, a variable-ratio friction device adjusts itself to compensate for differences in shaft speeds and to register a signal that varies as the ratio of the shaft speeds. When both shafts rotate at equal speeds, the friction disc of constant diameter D_2 takes an axial position along friction cone such that diameter D_1 equals D_2. Friction disc D_2 is mounted on its shaft in the manner of a threaded nut. If the disc and its supporting shaft rotate at un-

MINIATURE MOTOR PROTOTYPES

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PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS. TIMERS. STEPPERS. BLOWERS. FANS. MOTORIZED DEVICES

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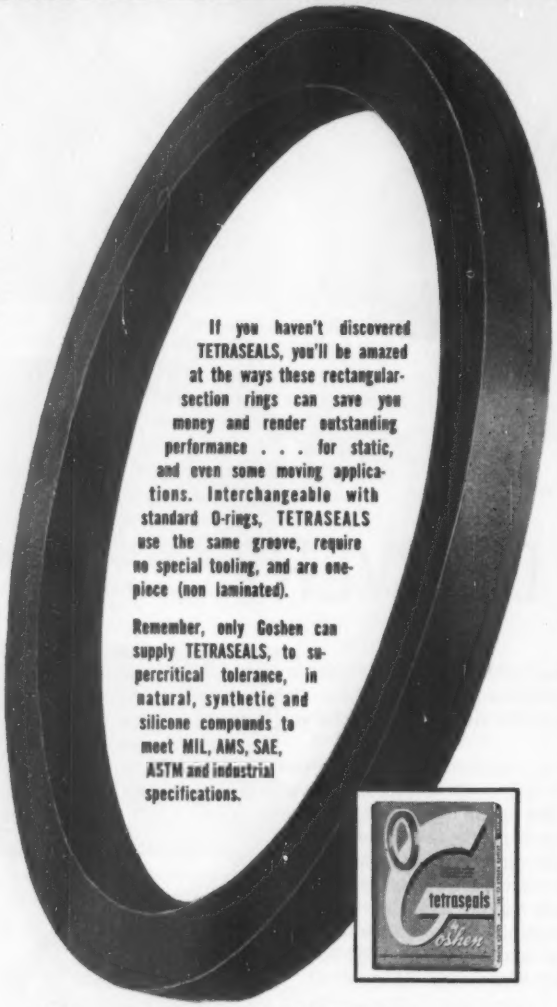

If you haven't discovered TETRASEALS, you'll be amazed at the ways these rectangular-section rings can save you money and render outstanding performance . . . for static, and even some moving applications. Interchangeable with standard O-rings, TETRASEALS use the same groove, require no special tooling, and are one-piece (non laminated).

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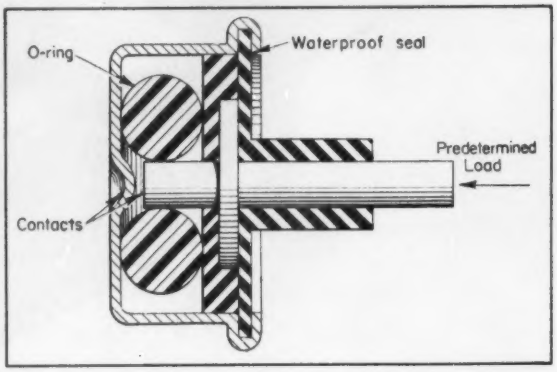
equal speeds, the difference in speeds causes the disc to move axially with respect to the shaft until equality in speeds is established. The axial position of the disc, in turn, provides the signal for speed ratio. *Patent* 2,949,781 *assigned to the Bendix Corp. by Howard L. McCombs Jr.*

Load-Closing Electric Switch

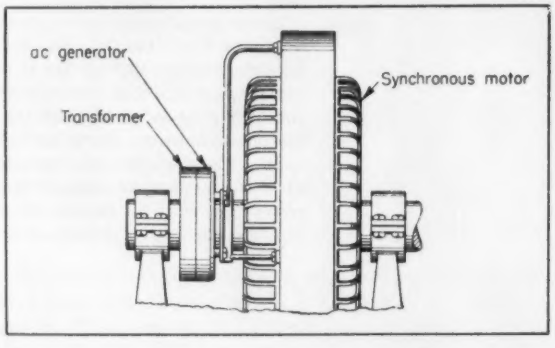
Suitable for circuits in which the resistance is of the order of 1000 megohms when the contacts are open, miniature switch uses an O-ring to keep the contacts open until a predetermined load is applied. When the



O-ring is a silicone elastomer, application temperature range is −40 to 160 F. The loading required to close the switch can be changed without disassembly of the switch by altering the dimpled surface in the case. *Patent* 2,952,754 *assigned to Union Carbide Corp. by Joseph R. Tomlinson and Terrence J. Kurtzweil.*

Shaft Current Neutralizer

Reduction of the shaft currents in rotating electric machines, such as a three-phase synchronous motor, is accomplished by an ac generator and a transformer inductively coupled to the shaft current circuit. The emf and frequency provided by the supplementary generator and transformer are made equivalent to the shaft emf

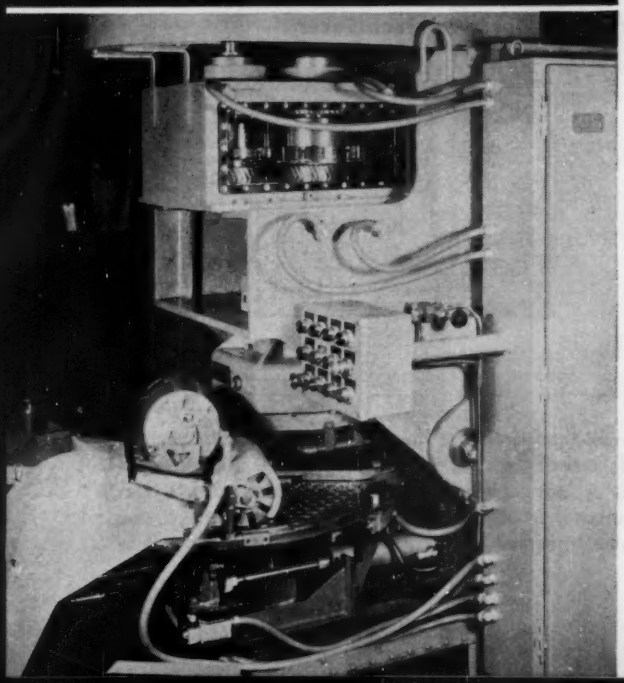


and frequency developed by the machine itself, but 180 deg out of phase. The core of the transformer encircles the motor shaft which forms the secondary of the transformer. The stator of the supplementary generator also encircles the shaft which carries the gen-

ANOTHER FAWICK USER REPORTS:

(Above) Zagar multiple-spindle nut tapping machine equipped with two Fawick Magnetic Clutches and one Magnetic Brake for full torque transmission at high cyclic rates. Machine has highest tapping capacity of all nut tapping machinery.

(Below) Fawick SC Magnetic Clutches control forward and reverse motion of spindle head, provide smooth action with shock-free engagement, work in visible oil splash environment.



"We specify Fawick Magnetics because they are among the very best on the market!"

So states Jim Tankard, Director of Machine Design at Zagar Incorporated, Cleveland machine tool manufacturer who uses Fawick Magnetic Clutches on their new multiple-spindle nut tapping machines that can outproduce all other known methods.

These machines can tap up to 100,000 nuts per hour as compared with the 4,000-unit average of single-tap machines. Split second cycling of heavy torque loads with smooth, instantaneous starting and stopping of the spindle head are essential. The Fawick units were chosen for the job in accordance with Zagar's stated policy of "... using only the finest components available".

Two SC Magnetic Clutches, one forward and one reverse, transmit torque from a motor-driven flywheel to the main drive crank of the gearless spindle head. Motor and flywheel run continuously and need for motor reversal is eliminated. As the tapping operation is completed, the forward clutch disengages and the SA Magnetic Brake stops the spindle head. The reverse clutch engages and taps are withdrawn from the work. Each cycle includes full engagement and disengagement of all three Magnetic units, working at tremendous torques, plus indexing of the work-holding plate . . . *all in less than five seconds!*

Imaginative designers like Zagar are putting Fawick Magnetics to work in hundreds of ways, but with a single purpose: to get the best in electric clutch and brake performance. For complete information contact your nearest Fawick representative, or write the Home Office, Cleveland, Ohio.

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INDUSTRIAL CLUTCHES AND BRAKES

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With or without self-locking threads. Hex collar prevents turning when torqueing bolt.

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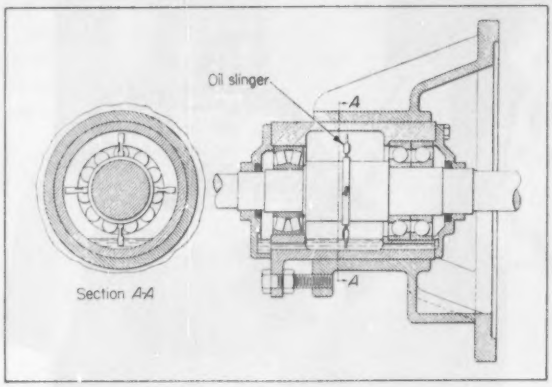
erator rotor. Opposing currents produced by the supplementary system substantially reduce or eliminate the shaft currents set up by the motor. *Patent* 2,951,166 *assigned to Electric Machinery Mfg. Co., Minneapolis, by Edwin W. Swanson.*

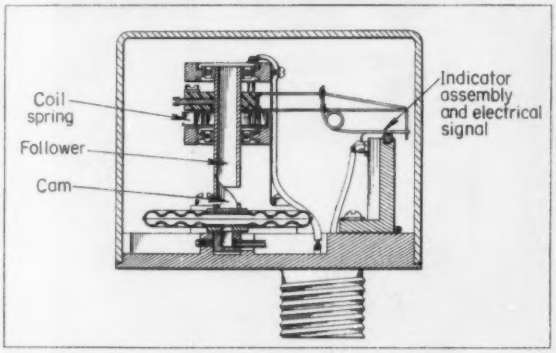
Slinger-Type Mist-Lubrication System



Oil slinger within a lubricant reservoir performs three functions: It scoops up oil from the bottom of the reservoir, churns the dispersed oil to a mist, and acts as a fan to circulate the mist through the bearings. Blades on the slinger, which may be oriented angularly in any arrangement to meet design and operating requirements, provide the churning and fan actions. *Patent* 2,950,943 *assigned to Allis-Chalmers Mfg. Co., Milwaukee, by Frank R. Forrest.*

Object detection system uses an infrared scanning system in which a single sensitive cell scans successive portions of an area. The output of the cell is delayed so that a difference in detected radiations of two successive scannings provides a signal. *Patent* 2,951,160 *assigned to Sperry Rand Corp. by Earl J. McCartney.*

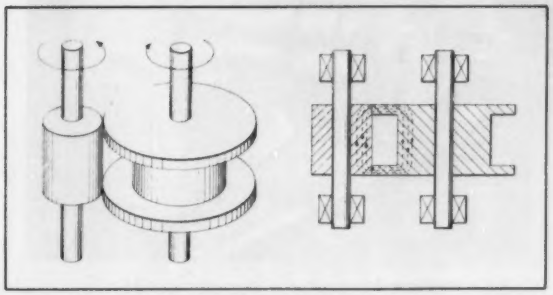
Mechanical-Electrical Transducer



Precise conversion of linear displacement into angular displacement for an electrical signal is accomplished by a cylindrical-cam assembly. The cam, which does not rotate, is displaced linearly along the axis of the follower member in response to pressure within a flex-

ible bellows. A helical surface on the cam contacts the follower, forcing it to move angularly because of restraint to axial displacement by bearings. A coil spring keeps the follower firmly in contact with the cam and actuates the return angular movement. The spring serves also as the electrical connection for the movable indicator assembly and output signal. The electrical assembly is light, rugged, and insensitive to vibrations and rapid changes in acceleration. *Patent* 2,951,225 *assigned to the Bristol Co., Waterbury, Conn., by Joffre Robert Hentzi.*

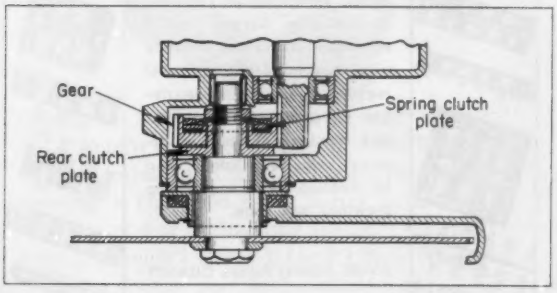
Magnetic-Traction Drive Mechanism



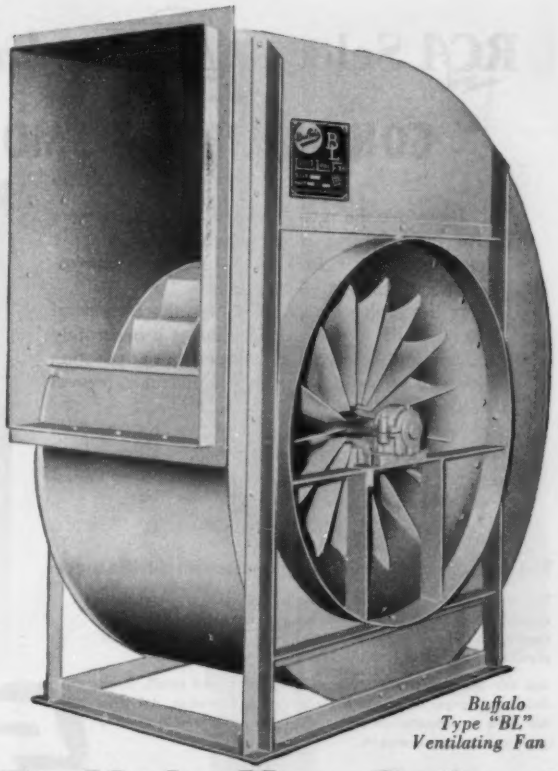
Permanently magnetized cylinder, with north and south poles at the ends, maintains traction magnetically at points of contact with a spool-shaped wheel. In operation, rotation of one member drives the other. The spool-shaped member is made of magnetic material that retains no fixed polarity. One shaft is supported by bearings that float relative to the other shaft; hence, traction forces produce no bearing loads and are not hindered by bearing reactions. *Patent* 2,951,387 *assigned to Sun Oil Co., Philadelphia, by William H. Cox.*

Slip Clutch

Uniform clutching action, despite repeated starts from stalls or stops, is provided in a slip clutch by an assembly consisting basically of a shaft with bearings, a gear, clutch plates on either side of the gear, and a nut-and-screw clamping arrangement which includes a conical disc spring. The clutch plates are made of sintered bronze and, preferably, are impregnated or



soaked with oil. The gear is a sintered steel alloy and has a web which is pinched between the clutch plates. *Patent* 2,952,146 *assigned to American-Lincoln Corp., Toledo, Ohio, by John P. Bruck.*



Buffalo Type "BL" Ventilating Fan

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IN DESIGNING A FAN INTO EQUIPMENT are you considering the important factors beyond the original price of that fan?

YOU KNOW that the equipment cannot function better than the fan — whether the fan is for cooling the equipment, exhausting or supplying air.

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4. Quality construction that insures years of trouble-free service.

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Circle 546 on Page 19

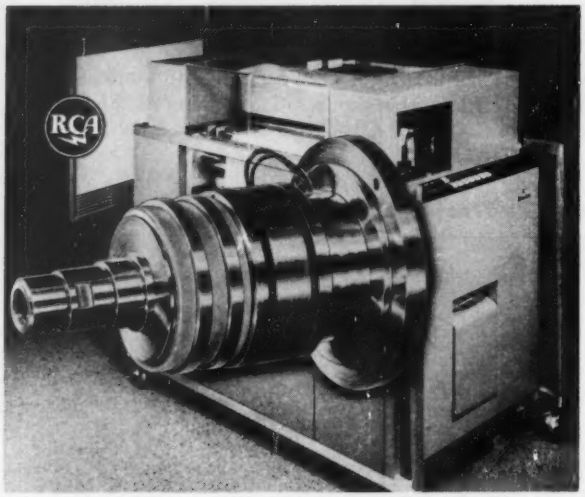
RCA Selects Simplatrol Electric Clutch Brake

CONSISTENCY – SMOOTHNESS – QUIETNESS

These are the reasons that R. C. A. engineers gave for selecting a Simplatrol CB-62 electric clutch-brake unit for use in its new electro-mechanical printer.

In this high speed application, the Simplatrol unit feeds the paper — and indexes it accurately for printing. Specially developed in cooperation with R. C. A. engineers, the Simplatrol unit gives "remarkable consistency".

In the tape drive section of the unit, the Simplatrol clutch-brake delivers a smoothness and quietness not previously available, and so necessary in business machines.



R.C.A. 501 Data Processing System — Electro-mechanical Printer

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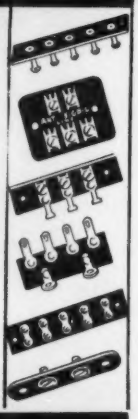

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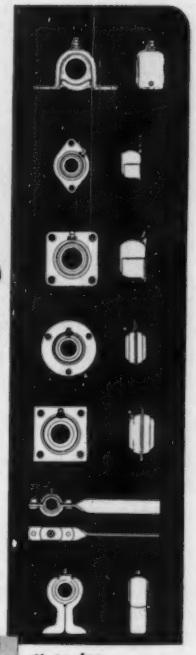

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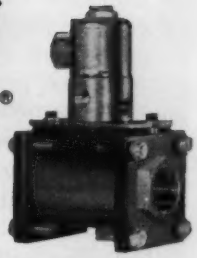

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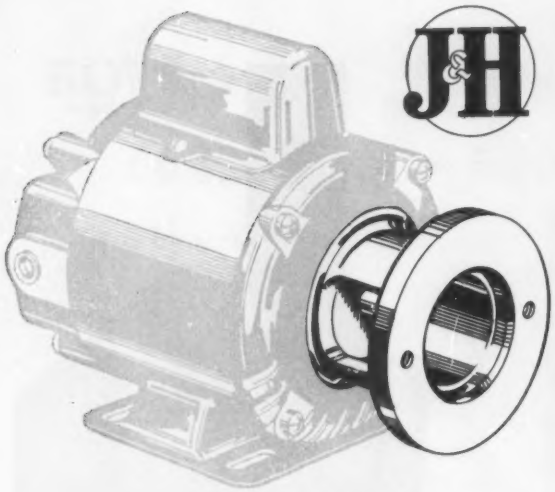
Circle 552 on Page 19



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SPEEDS: 3450, 1725 or 1140 rpm
FRAME: J66 or special
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ELECTRIC MOTORS

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The Two-Way Payout feature on Gleason Reels permits cable control to *both sides* of travel center. You need only one-half the usual cable length. This is only one of many Gleason advantages that provide twist-proof cable protection and smooth power control to equipment in motion. Available in many types and sizes, also in watertight, dust-tight, or explosion-proof type construction.

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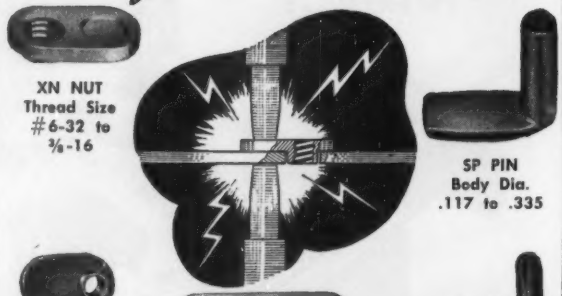

If you do spotwelding you can attach OHIO Spot-weld Fasteners at the same time for faster, trouble-free assembly.

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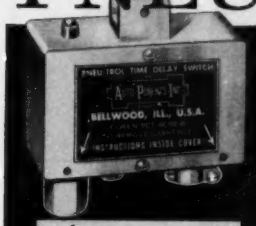
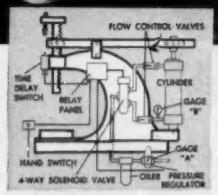


AUTOMATION TIME DELAY SWITCH

FOR CONTROLLED TIME DWELL OF AIR OR HYDRAULIC CYLINDERS



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- Designed for millions of actuations

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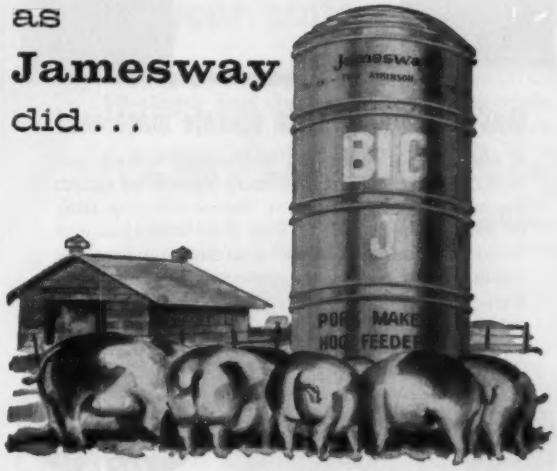

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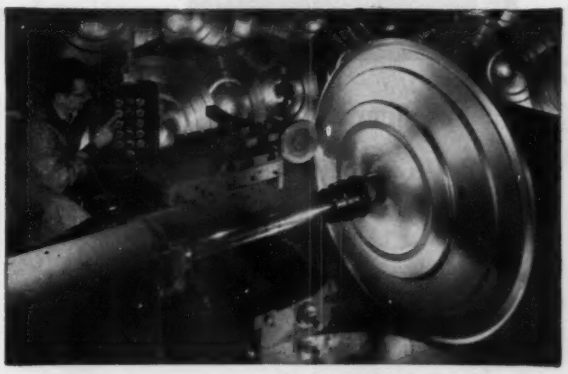

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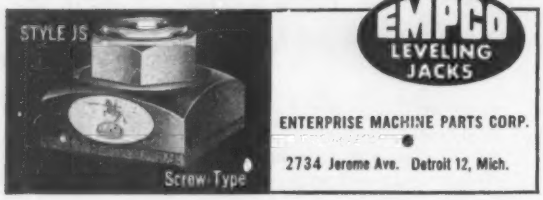

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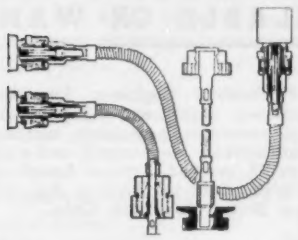

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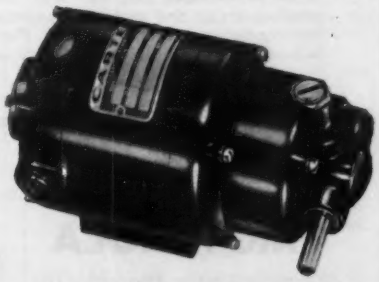

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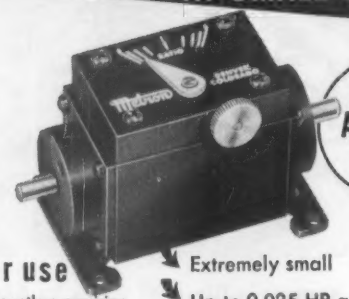

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BPA NEP

backtalk——

—Man Bites Dog

The supposed shortcomings of design engineers in designing for economical manufacture are a familiar refrain among production engineers. Some of the latter even spend time composing lengthy "poems" ending with a punch line such as "success at last—it can't even be cast!" Such compositions are always good for a laugh.

We heard of a new twist the other day. Analysis of motion and forces in a newly devised mechanism was needed. After a brief study of the proposal, the engineer suggested a minor design change in the mechanism that would greatly simplify the analysis without affecting the function of the device. The draftsman drew himself up to his full height and huffed, "I am not in the habit of designing mechanisms to make the analysis easy."

—One for the Books

If people nowadays followed the custom of taking surnames that described their activities, our Jim Parks would have had to change his, because he seldom does. Parks, that is. Jim always seems to be on the move, involved in civic, athletic, educational, or church projects.

He matriculated at Ohio Northern University in 1949, interrupted his studies because of the Korean conflict, then returned to college to earn a degree in civil engineering. Since then he has taken further courses in mechanical engineering and management. This fall he is vice chairman of a session on drives and controls for the technical education program of Cleveland Engineering Society.

Jim was a research and development engineer for Pesco Products Div. of Borg Warner before coming to MACHINE DESIGN. He joined our staff as an assistant editor in March of 1958 and was made an associate editor about a year ago. He is now co-ordinator and one of the planners of our newly established *Books* program.

Jim belongs to SAE, ASCE, AIEE, an honorary engineering fraternity, and is a Registered Professional Engineer.

Activities that have kept him from being a dull boy in the years we have known him include competitive sports (baseball, golf, and bowling) and his roles in his church's annual minstrel shows. Besides being a Mr. Bones, he has also helped direct and write the shows, as befits an editor.

—Seating Pretty

Speaking of Bones, don't be alarmed when you behold the several pictures of skeletons in the next issue of MACHINE DESIGN. We are not trying to make like a medical journal, nor are we overcome by the spirit of the Halloween season—the "phantom" views serve the worthwhile purpose of illustrating an article entitled "Seats for People."

Prepared by the Henry Dreyfuss organization, the article deals with the design and selection of seating for operator comfort and efficiency. It provides a good deal of information of use to seat specifiers and of interest to anyone who sits. It tells about first impressions, a human's proprioceptive sense, posture, support, pressures, and soft tissue, to name but a few things.

And we'll wager that while you're reading the article, you'll begin to squirm around in your chair to try to find a more comfortable position.

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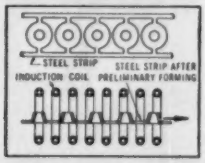
TYPICAL INDUCTION HEATING APPLICATIONS

PLASTIC COATING OF TOOL HANDLES

A production line operation for coating handles of tools at Whitney Metal Tool Co., Rockford, Ill. uses induction heating with excellent results. The handles only are heated by induction to the desired temperature then dipped into a vinyl chloride base coating material for a short period depending upon the thickness of coating desired. The plastic coating formed on the handles is then cured by immersion in a carbo-wax bath.

FORMING OF METAL STRIP FACILITATED BY PROGRESSIVE ANNEALING



Metal forming operations which require intermediate anneals to restore ductility can be facilitated by induction annealing the strip progressively. Diagram illustrates this procedure for partially formed thin austenitic stainless steel strip. The induction annealing operation is scheduled in the production line between two press operations. Metal strip and wire of other materials are also induction annealed in this manner.

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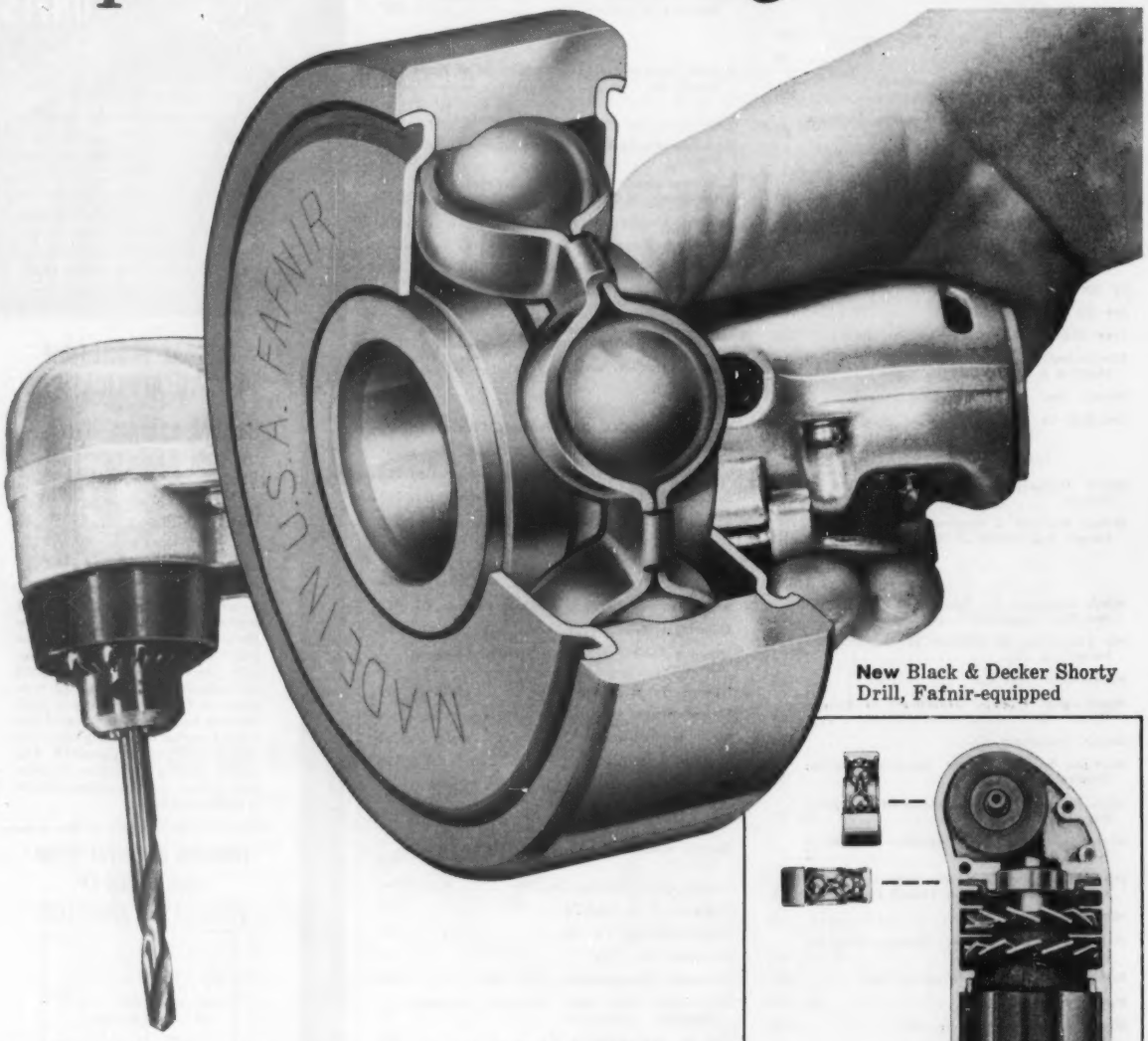
FAFNIR BALL BEARINGS
help new drill turn tight corners

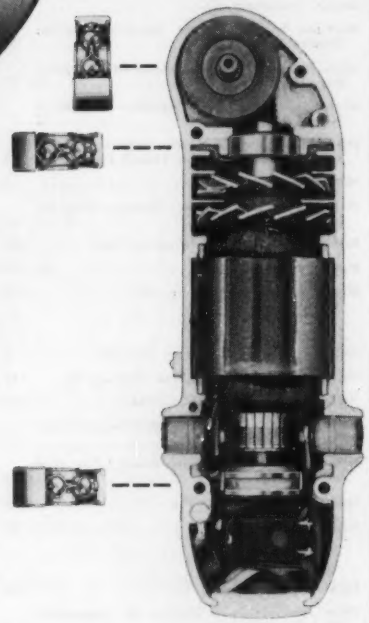


New Black & Decker Shorty Drill, Fafnir-equipped

Black & Decker's unique new "Shorty" Drill works where other drills won't . . . in tight spots . . . around corners. In this compact tool, Fafnir Ball Bearings meet space-saving requirements and provide the stamina and precision needed for heavy-duty drilling.

Fafnir extra-small shielded ball bearings are used on the chuck end of the spindle and commutator end of the armature. A third Fafnir Ball Bearing with Plya-Seal and Shield supports the fan end of the armature. All are permanently prelubricated, with their own built-in protection against grease seepage and contaminants. Thrust loads are adequately sustained by the ball bearings selected.

For the ball bearings *you* need, write The Fafnir Bearing Company, New Britain, Conn.



Fafnir Ball Bearings support armature and spindle in "Shorty" Drill . . . save space, maintenance . . . help keep parts rigidly aligned, true-running.

FAFNIR
BALL BEARINGS

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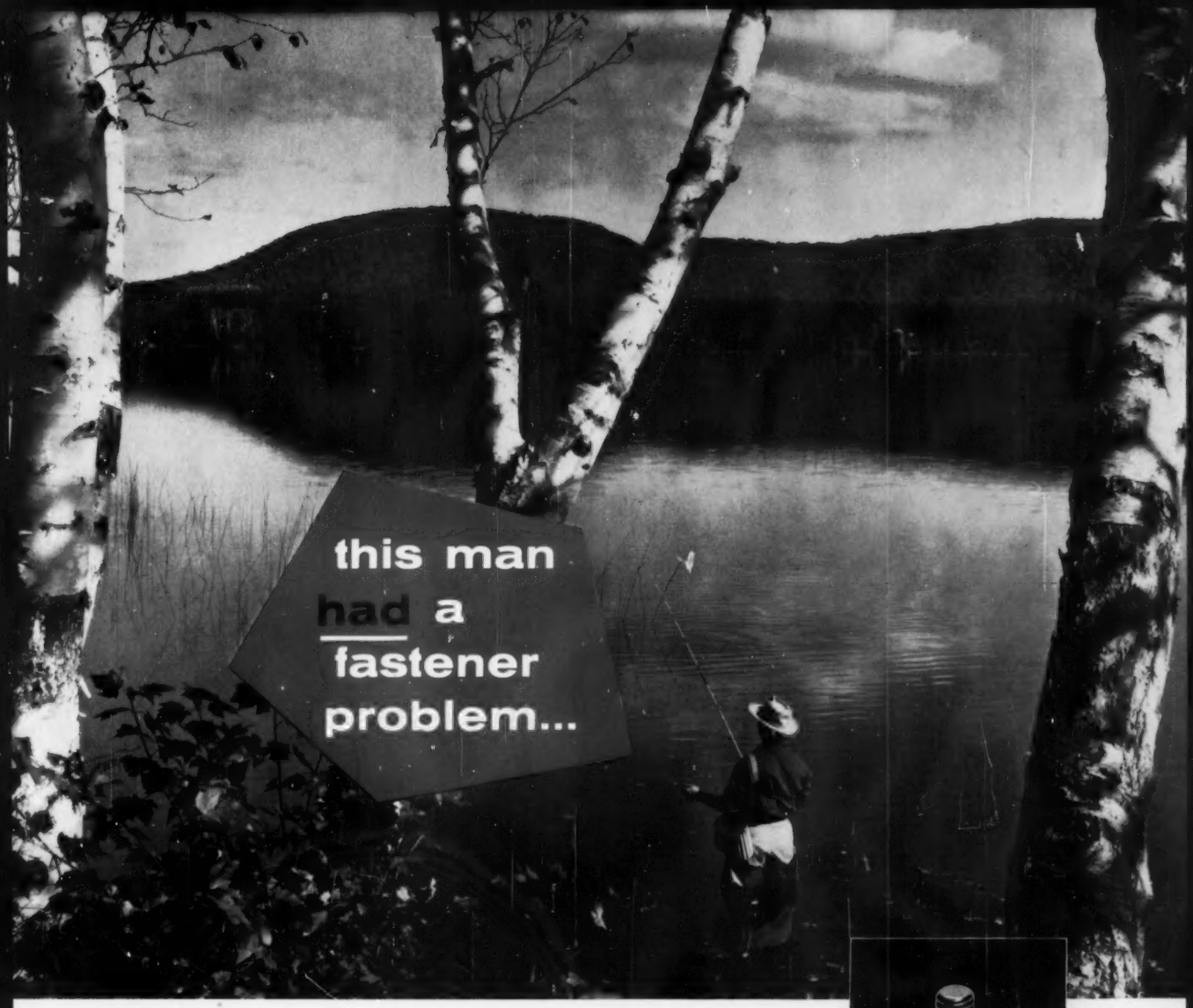

and here's how Pheoll solved it

A recent development by Pheoll has made this fisherman's regular job a lot easier. The job . . . that of electrician.

Specifically, Pheoll has done away with all the red tape—or should we say "black tape"—involved in setting up wiring systems. Now, to make an electrical connection there's no need for tape to tape and tape the wires together. A set of Pheoll designed shouldered brass screws, built into a small plastic case, form handy binding posts around which the wires can be wound and joined. The electrician clamps on the lid, screws it down tight . . . and the connection is made . . . quickly and permanently. No tape deterioration. No shorts.

This is typical of Pheoll experience . . . the application of creative engineering to basic, everyday fastener problems . . . that can be helpful to your company.

Why not call or write Pheoll today?

Pheoll Manufacturing Company, Inc.
5700 WEST ROOSEVELT ROAD CHICAGO 50, ILLINOIS

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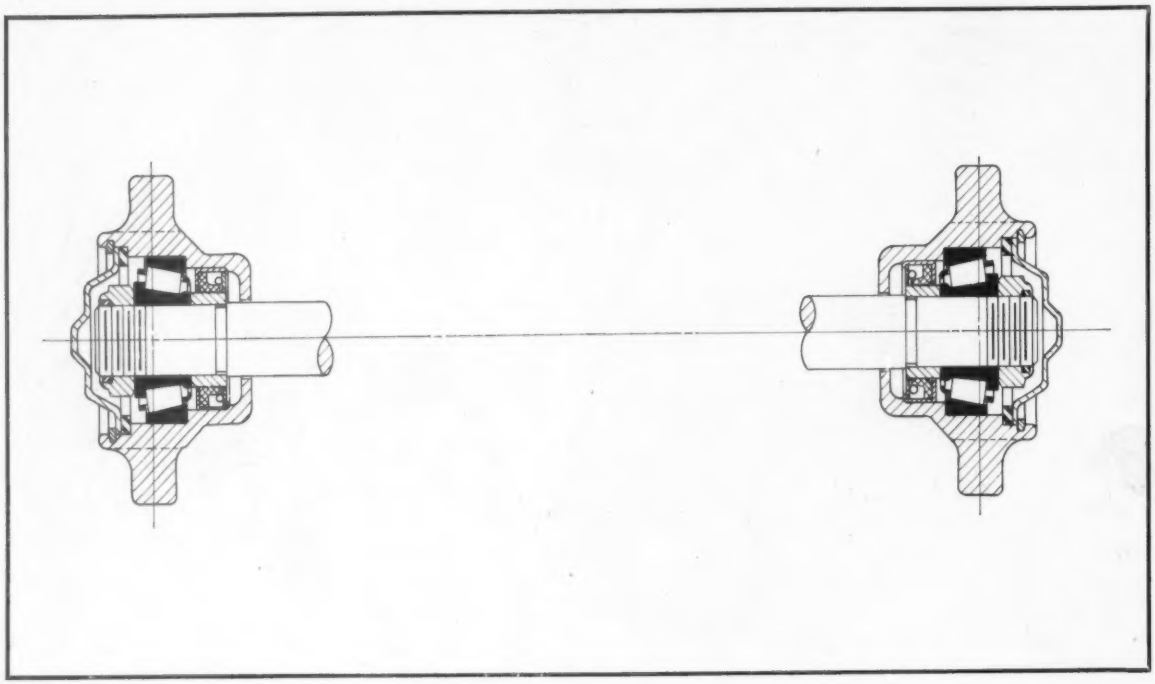
PHEOLL P

HEADING THE FASTENER INDUSTRY FOR OVER 50 YEARS

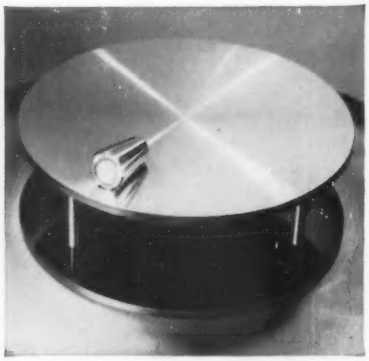
HOW JOY MOUNTS IDLERS TO FIGHT WEAR FROM DIRT AND DUST



By designing their Limberoller® two-bearing, single-unit catenary idlers to use Timken® single-row tapered roller bearings (see above), Joy Manufacturing engineers reduce bearing failures caused by dirt, dust, moisture . . . assure spillage-free conveying and trouble-free idler performance. Timken bearings hold the idlers on center at all times, increase sealing efficiency. Idlers roll easily under heaviest loads, belt moves smoothly.

On these applications, Timken bearings assure minimum maintenance, long bearing life because: 1) They hold shafts concentric with housings, making closures more effective in keeping lubricant *in*, dirt *out*. 2) The tapered construction of Timken bearings lets them take radial and thrust loads in any combination.

ENGINEERING SERVICE FOR THE ASKING. Let our Timken bearing salesmen—graduate engineers—tackle your bearing problems, solve them in a hurry. Save *you*—time and money.



ROLLS FOREVER IN PERFECT CIRCLE on oscillating table, proving the accuracy of its taper. Another demonstration of Timken bearings' precision manufacture that assures trouble-free performance.

Industry rolls on

TIMKEN®

tapered roller bearings

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO." *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.* Canadian Division: Canadian Timken, St. Thomas, Ont.

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